Liège 23.06.2022 Endovascular repair of the arch





The European Society for Cardiovascular and Endovascular Surgery

Customized devices and solutions: The encouraging up today experience

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No disclosures









Aortic arch treatment options From open to hybrid...







Aortic arch treatment options ...up to personalyzed ev solutions...





Aortic arch treatment options ... that allow a zone-0-to-2 treatment!





Endovascular treatment of aortic arch A structured procedure

- Endograft design
- Learning curve (patient selection, SCI prevention)
- Dedicated stents
- Intraoperative imaging (fusion imaging, cone-beam CT)





Endovascular repair of the aortic arch Evolution in endograft design

Off-the-shelf

- Gore TBE
- Medtronic Mona-LSA
- Endospan Nexus

Custom-made

- Cook
- Bolton
- Najuta









The Initial Experience on Branched and Fenestrated Endografts in the Aortic Arch. A Systematic Review

Carla Lorena Blanco Amil, Gaspar Mestres Alomar, Giorgio Guarnaccia, Giorgio Luoni, Xavier Yugueros Castellnou, Rossella Chiara Vigliotti, <u>Rafic</u> Ramses, and Vincent Riamb

- **29 studies** (28 retrospective, 1 prospective)
- Intraoperative stroke rate: 4.8%
- In-hospital mortality: 2.5%
- Conclusion: published experience showed <u>acceptable short-term</u> <u>effectiveness and safety</u>. More wellconducted prospective clinical studies with long term follow-up, combined with comparative metaanalysis

Table V. Intraoperative Complications Reported in Total Cases of bEVAR/fEVAR.

Event	Number of patients	Percentage (%)
Endoleaks	36	5.2
Stroke	31	4.8
Iliac or site access bleeding/rupture/pseudoaneurysm	23	4.1
Transfusion	12	2.9
Spinal cord ischemia	9	1.5
Dissections	5	0.9
Open conversion	3	0.5
Myocardial infarction	2	0.3
Unwanted LSA occlusion	1	0.4
Unwanted celiac occlusion	1	0.2

Table VI. Mortality during follow-up related to the main operation.

Deaths during follow up related to the main operation	Number of patients	Percentage (%)	
Total	22	4.8	
Pneumonia	6	27.3	
Sudden/unknown	5	22.7	
Aorta-esophagical fistula	2	9.1	
Systemic embolisation	2	9.1	
Sepsis	2	9.1	
Thrombotic thrombocytopenic purpura	1	4.5	
Disseminated intravascular coagulation	1	4.5	
Dissection	1	4.5	
Cardiac arrest	1	4.5	

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Branched versus fenestrated thoracic endovascular aortic repair in the aortic arch: A multicenter comparison

Sven R. Hauck, MD,^a Alexander Kupferthaler, MD,^{a,b,c} Maximilian Kern, MD,^d Hervé Rousseau, MD,^e Ciro Ferrer, MD,^f Shinichi Iwakoshi, MD,^g Shoji Sakaguchi, MD,^h Marie-Elisabeth Stelzmüller, MD,ⁱ Marek Ehrlich, MD,ⁱ Christian Loewe, MD,^a and Martin A. Funovics, MD^a

Characteristic	All TEVAR $n = 54$ no. %	Terumo n = 20 no. %	Najuta n = 34 no. $\%$	P (CI) Terumo vs Najuta
Technical success	53 (98.1%)	20 (100%)	33 (97.1%)	1.0000
Major complications 30 d Mortality§ Major stroke Minor stroke Other	8 (14.8%) 2 (6.3%) 3 (5.6%) 1 (1.9%) 3 (5.6%)	6 (30%) 2 (10%) 2 (10%) 1 (5%) 2 (10%)	2 (5.90%) 0 (0%) 1 (2.9%) 0 (0%) 1 (2.9%)	.0410 .1328 .5476 .3703 .5477
Minor complication 30 d¶	3 (5.6%)	3 (15%)	0 (0%)	.0460
Follow-up, mo	35.8 (±38.2)	30.7 (±21.0)	40.3 (±42.6)	1.0000
Late mortality Unrelated	18 (33.3%)	7 (35%)	11 (32.4%)	1.0000
Aortic#	1 (1.9%)	0(0%)	1 (2.9%)	1.0000
Stability of success Late EL** Branch occlusion Stent migration	47 (87%) 2 (3.7%) 1 (1.9%) 0 (0%)	19 (95%) 0 (0%) 1 (5%) 0 (0%)	28 (82.4%) 2 (5.9%) 0 (0%) 0 (0%)	.2393 .5248 .3704
Aortic reintervention	6 (11.1%)	1 (5%)	5 (14.7%)	.3947

J Thorac Card Vasc Surg 2020



Endovascular repair of the aortic arch Scalloped and Fenestrated graft





Fenestrated endovascular repair for diseases involving the aortic arch

Nikolaos Tsilimparis, PhD,^{a,b} Yuk Law, FRCS,^a Fiona Rohlffs, MD,^a Konstantinos Spanos, MD,^a Eike Sebastian Debus, PhD,^a and Tilo Kölbel, PhD,^a Hamburg and Munich, Germany

ARTICLE HIGHLIGHTS

- Type of Research: Single-center, retrospective cohort study
- Key Findings: Among 44 patients who underwent fenestrated arch thoracic endovascular aortic repair, technical success was 95%, 30-day mortality was 9%, and major stroke occurred in 7%. Three patients needed early reintervention, whereas 10 patients required secondary intervention to complete the treatment of an underlying disease.
- Take Home Message: Fenestrated endograft repair of aortic arch disease is a feasible technique with high technical success and acceptable operative morbidity and mortality.

	Zone 0 (n = 12)	Zone 1 or 2 (n = 32)	P value
30-Day mortality	1 (8)	3 (9)	1
Stroke	1 (8)	3 (9)	1
Paraplegia	1 (8)	2 (6)	1
Retrograde type A dissection	1 (8)	O (O)	.273
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"Categorical variables are compared with Fisher exact test.



Fig 3. Kaplan-Meier curves for (A) overall survival, (B) freedom from reintervention, and (C) freedom from targeted vessel occlusion or stenosis.

Pre-Loaded Fenestrated Thoracic Endografts for Distal Aortic Arch Pathologies: Multicentre Retrospective Analysis of Short and Mid Term Outcomes

Nikolaos Tsilimparis ^{a,*,*}, Carlota F. Prendes ^{a,‡}, Guido Rouhani ^b, Donald Adam ^c, Nuno Dias ^d, Jan Stana ^a, Fiona Rohlffs ^e, Kevin Mani ^f, Anders Wanhainen ^t, Tilo Kölbel ^e

- 108 patients
- Median follow-up 12months (range 1-26)
- Technical success 99% (n=107)
- 30-day mortality rate 3.7% (n=4)
- 30-day major stroke 5.6% (n=6)
- 30-day spinal cord ischemia 3.7% (n=4)
- Follow-up type IA EL 3.5% type IB EL 2.9%
- 1-2-3 year survival rate
 - 93.2%, 92.1% and 89.1%





Figure 4. Cumulative Kaplan—Meier estimate of survival in a multicentre retrospective cohort of 108 patients treated by fenestrated thoracic endovascular aortic repair (f-TEVAR) stent graft for distal aortic arch pathology. Only 99 patients are reported at time zero because nine patients had no follow up data and were therefore excluded from this analysis.

Conclusion: This multicentre study shows that treatment of the distal aortic arch by f-TEVAR is feasible, with promising 30 day mortality, stroke, and spinal cord ischaemia rates.



Long-Term Clinical Outcomes of Thoracic Endovascular Aortic Repair for Arch Aneurysms with the Najuta Thoracic Stent-Graft System

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- 37 patients
- Mean follow-up **2,9 ± 2,9 years**
- Technical success 97.3% (36/37)
- Postoperative type IA EL 27.8% (n=10)
- Postoperative stroke 16.7% (n=6)
- Postoperative paraplegia 2.8% (n=1)
- At 1-3-5-7 years
 - Overall survival rates: 96.4%-90.8%-83.2%71.3%
 - Freedom from aorta-related events: 90.5%, 65.8%, 50.7%, 50.7%





Ann Vasc Dis 2020

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0.8

Aliptequal 0.4

0.2

0.0

Endovascular repair of the aortic arch Branched endograft





Management of arch aneurysms with a single-branch thoracic endograft in zone 0



JTCVS Tech 2021

Michael D. Dake, MD,^a Joseph E. Bavaria, MD,^b Michael J. Singh, MD,^c Gustavo Oderich, MD,^d Mark Filinger, MD,^e Michael P. Fischbein, MD, PhD,^f Jon S. Matsumura, MD,^g and Himanshu J. Patel, MD^h

- Multicenter US feasibility study GORE TBE device
- Technical success 100%
- 30-day mortality or spinal cord ischemia 0%
- 30-day cerebrovascular events: 2 patients (2/9, 22,2%)
- 12-month type I or III endoleaks: 0%
- 12-month side branches patency: 100%

Conclusions: Endovascular repair of Ishimaru zone o or 1 arch aortic aneurysms can be achieved with a novel branched arch endograft. Future studies will evaluate the mid-term outcomes with this device in other pathologies and further define the occurrence of postoperative neurologic events. (JTCVS Techniques 2021;7:1-6)





iTalian RegIstry of doUble inner branch stent graft for arch PatHology (the TRIUmPH Registry)



Ciro Ferrer, MD,^a Piergiorgio Cao, MD, FRCS,^b Carlo Coscarella, MD,^c Michelangelo Ferri, MD,^d Luigi Lovato, MD,^a Stefano Camparini, MD,^f and and Luca di Marzo, MD,^a on behalf of the TRIUmPH Registry Investigators,^{*} *Rome, Turin, Bologna, and Cagliari, Italy*

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective study of prospectively collected multicenter registry data
- **Key Findings:** In 24 patients undergoing endovascular aortic arch repair with double inner branch stent graft, in-hospital mortality, major stroke, and retrograde dissection occurred in 16.7%, 12.5%, and 8.3%, respectively. During follow-up of 18 months (range, 1-60 months), no patient died of aortic cause or required secondary intervention, and most aneurysm sacs decreased in diameter.
- **Take Home Message:** Endovascular aortic arch repair with double inner branch stent graft is feasible, and results are acceptable for a new technique in a high-risk subset of patients.



Table III. Early results

Early results (N = 24)	n/N or median (IQR)	% or range
In-hospital mortality	4/24	16.7
Cause		
Aortic rupture after retrograde dissection (POD 2)	1/24	4.2
Respiratory arrest after stroke of the basal ganglia (POD 3)	1/24	4.2
Hemorrhagic shock after ascending aorta replacement for retrograde dissection (POD 16)	1/24	4.2
Pulmonary infection after stroke (POD 48)	1/24	4.2
Cerebrovascular complications	6/24	25
TIA	3/24	12.5
Stroke	3/24	12.5
Retrograde dissection	2/24	8.3
Endoleak	2/24	8.3
Type I	0/24	0
Type II	2/24	8.3
Type III	0/24	0
Renal insufficiency	1/24	4.2
Transient dialysis	1/24	4.2
Early secondary procedures	4/24	16.7
Ascending aorta replacement for retrograde dissection	1/24	4.2
Surgical revision for cervical bleeding	3/24	12.5
Composite end point	10/24	41.7
Hospitalization time, days	11.5 (10-21)	8-49
ICU stay, days	1.5 (1-4)	0-49
ICU, Intensive care unit; IQR, interguartile range; POD, postoperative day; TIA, transi	ent ischemic attack.	



Multicenter global early feasibility study to evaluate total endovascular arch repair using three-vessel inner branch stent-grafts for aneurysms and dissections

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F. Ezequiel Parodi, MD,^d Carlos H. Timaran, MD,^e Carla K. Scott, MD,^e Nikolaos Tsilimparis, MD, PhD,[†] Carlota Fernandez, MD,[†] Tomasz Jakimowicz, MD, PhD,⁹ Katarzyna Jama, MD,⁹ Jarin Kratzberg, PhD,^h Justine Mougin, MD,[†] and Stéphan Haulon, MD, PhD,[†] *Houston and Dallas, Tex: Hamburg and Munich, Germany: Malmö, Sweder; Chapel Hill, NC; Warszawa, Poland; Bloomington, Ind; and Gif-sur-Yvette, France*

ARTICLE HIGHLIGHTS

 Type of Research: A multicenter, retrospective study Key Findings: A total of 39 patients (31 men [79%]; mean age, 70 \pm 7 years) had undergone treatment of 14 degenerative (36%) and 25 chronic (64%) postdissection arch aneurysms with a three-vessel inner branch stent-graft. Technical success was achieved in all 39 patients. Two patients died in-hospital (5%) and two experienced a stroke (5%). The combined mortality and any stroke rate was 8% (n = 3). Of the 39 patients, 12 (31%) had required secondary interventions. No retrograde type A dissection occurred. · Take Home Message: The results from the present multicenter global experience have demonstrated the technical feasibility and safety of total endovascular aortic arch repair for aneurysms and chronic dissections using three-vessel inner branch stentgrafts. The mortality and stroke rates compare favorably to those after open surgical repair in a higher risk group.



Table III. Mortality and major adverse events <30 days (n = 39)

J Vasc Surg 202

Variable	No. (%)
Early death	2 (5)
Any major adverse event	10 (26)
Estimated blood loss >1 L	2 (5)
Acute kidney injury	2 (5)
New-onset dialysis	1 (2.5)
Myocardial infarction	2 (5)
Respiratory failure	4 (10)
Any spinal cord injury	O (O)
Any stroke	2 (5)
Major stroke	1 (2.5)
Minor stroke/TIA	1 (2.5)
Bowel ischemia	1 (2.5)
TIA Transient ischemic attack	



Aortic arch treatment Critical issues

Complex lesions

 Supraortic and visceral vessels involvement, intercostal and pelvic arteries, accesses (SAV or femoral)

Complex treatments

 Risk of stroke, paraplegia, renal failure





Eur J Vasc Endovasc Surg (2019) 57, 165-198

Editor's Choice — Current Options and Recommendations for the Treatment of Thoracic Aortic Pathologies Involving the Aortic Arch: An Expert Consensus Document of the European Association for Cardio-Thoracic Surgery (EACTS) & the European Society for Vascular Surgery (ESVS)

Martin Czerny ^{a,*}, Jürg Schmidli ^a, Sabine Adler ^a, Jos C. van den Berg ^a, Luca Bertoglio ^a, Thierry Carrel ^a, Roberto Chiesa ^a, Rachel E. Clough ^a, Balthasar Eberle ^a, Christian Etz ^a, Martin Grabenwöger ^a, Stephan Haulon ^a, Heinz Jakob ^a, Fabian A. Kari ^a, Carlos A. Mestres ^a, Davide Pacini ^a, Timothy Resch ^a, Bartosz Rylski ^a, Florian Schoenhoff ^a, Malakh Shrestha ^a, Hendrik von Tengg-Kobligk ^a, Konstantinos Tsagakis ^a, Thomas R. Wyss ^a

Table 1

Unique characteristics of the aortic arch

Stroke remains a major concern during endovascular arch repair, with rates between 0 and 14%.^{197–199} The

Factor	Endovascular Concerns
Arch curvature	Trackability and conformity Endograft apposition, seal
Greater pulsatility and flow, dynamic strain	Risk of stent migration, kinking, or fracture Windsock movement of endograft before fixation
Supra-aortic branching	Cerebrovascular perfusion Landing zone limitations
Procedural	Atheroemboli, vascular injury, retrograde type A dissection

Recommendation 30

Endovascular aortic arch repair in zone 0 should be considered in patients unfit for open surgery and with a suitable anatomy

Class	Level	References
IIa	В	[199,203]

-



BJS, 2022, **109**, 46–52 DOI: **10.1093/bjs/znab341** Advance Access Publication Date: 25 October 2021 Original Article

Cerebral microbleeds following thoracic endovascular aortic repair

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Table 2 Anatomical location of cerebral microbleeds

	No. of patients (n=91)
No. of patients with at least 1 lesion	58 (63.7)
No. of CMBs	
Overall (among 58 of 91 patients)	1531
Mean(s.d.)	26.4(35.9)
Hemisphere	
Right alone	9 (15.5)
Left alone	3 (5.2)
Bilateral	46 (79.3)

Table 6 Multiple linear regression models with Firth correction

	β*	Odds ratio†	Р
Intercept	-0.375(1.123) (-2.665, 1.775)	0.687 (0.070, 5.898)	0.725
Stent diameter ≥ 40 mm	1.924(0.816) (0.501, 3.728)	6.851 (1.651, 41.590)	0.007
Compliant balloon	0.662(0.784) (-0.747, 2.206)	1.938 (0.474, 9.081)	0.359
Fazekas score, DWM	0.962(0.529) (0.054, 2.069)	2.618 (1.056, 7.917)	0.037
Fazekas score, PVWM	-0.680(0.561) (-1.770, 0.290)	0.507 (0.170, 1.337)	0.172
Unplanned reoperations	-2.302(1.146) (-4.803, -0.313)	0.100 (0.008, 0.731)	0.021
Spinal cord ischaemia	1.367(2.227) (-2.057, 6.709)	3.922 (0.128, 819.754)	0.455

*Regression parameter (f) with standard error then 95 per cent confidence intervals in parentheses. †Values in parentheses are 95 per cent confidence intervals. The parameter estimate of the multiple model was adjusted for stent diameter, compliant balloon, Fazekas score for periventricular white matter (PVWM) and deep white matter (DWM), unplanned reoperations owing to primary operation, and spinal cord ischaemia.

Values in parentheses are percentages unless indicated otherwise. CMB, cerebral microbleed.

Conclusion: CMBs on postoperative MRI are common after endovascular repair in the aortic arch. Their occurrence appears to be associated with key aspects of the procedure and pre-existing vascular leucoencephalopathy.



Endovascular treatment of aortic arch The other players on the field





Endovascular aortic arch repair Carefull patient selection





Endovascular aortic arch repair Focus on anatomy

Proximal landing zone

- Lenght
- Size
- Angulation
- Previous ascending repair
- Discrepancy with distal landing zone
- Arch variability
 - Anatomical variations
 - Variable branch vessels take off
 - Dissected arch
 - Dissected supra-aortic trunks
- Access vessels





Endovascular aortic arch repair The setting

Editor's Choice — Current Options and Recommendations for the Treatment of Thoracic Aortic Pathologies Involving the Aortic Arch: An Expert Consensus Document of the European Association for Cardio-Thoracic Surgery (EACTS) & the European Society for Vascular Surgery (ESVS)

1.4.1. Aortic team definition. The WC advocates that an aortic team should be closely involved from diagnosis to treatment and finally follow-up and should be led by members from cardiac and vascular surgery in collaboration with anaesthesiology, cardiology, radiology and genetics. A major advantage of surgery as the leading specialty is that surgeons have experience linking radiographic findings to tissue quality, which is a major component when opting for open surgery or endovascular treatment.

Eur J Vasc Endovasc Surg (2019)

Recommendation 1				
Decision making for the treatment of aortic arch pathologies by an aortic team is recommended				
Class Level References				
I	С	-		

Recommendat	ion 2		
Centralization recommended	of care for	aortic arch pathologie	es is
Class	Level	References	
I	С	•	

Recommendation 3		
Treatment of elective aortic arch pathology is recommended to be performed in specialized centres providing open and endovascular cardiac and vascular surgery on site only		
Class	Level	References
I	С	-



Ospedale Policlinico San Martino – University of Genoa Multidisciplinary team & dedicated ICU





The importance of the Hub and spoke model



Ospedale Policlinico San Martino – University of Genoa Hybrid room & adjuncts







- Endovascular treatment of aortic arch is still growing, thanks to device and technique improvement
- Carefull patient selection
- Centralization in high volume and expertise centers
- Do not convert an easy open procedure to a complex endovascular one



Thank you for your attention

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OSPEDALE POLICLINICO SAN MARTINO Sistema Sanitario Regione Liguria Istituto di Ricovero e Cura a Carattere Scientifico