Spinal ischemia session

How many stages is enough?

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Disclosures

- Co-PI / research coordinator for thoracic and abdominal aortic stent graft trials (Cook®, Cardinal health, Trivascular™, Medtronic, Gore®)

- Participated as a lecturer at symposia hosted by Cook®, Cardinal health, Jotec Gmb, Gore®.

- Consultant for Cook®, Jotec Gmb, Cardinal health

Spinal preconditioning with procedural staging

Open TAAA repair

ACQUIRED CARDIOVASCULAR DISEASE

Staged repair significantly reduces paraplegia rate after extensive thoracoabdominal aortic aneurysm repair

Christian D. Etz, MD, PhD,[a] Stefano Zoli, MD,[a] Christoph S. Mueller, MS,[a] Carol A. Bodian, DrPH,[b] Gabriele Di Luozzo, MD,[a] Ricardo Lazala, MD,[a] Konstadinos A. Plestis, MD,[a] and Randall B. Griepp, MD[a]

Objective: Paraplegia remains a devastating, and still too frequent, complication after repair of extensive thoracoabdominal aortic aneurysms. Strategies to prevent ischemic spinal cord damage after extensive segmental artery sacrifice—or occlusion, essential for endovascular repair—are still evolving.

Methods: Ninety patients who underwent extensive segmental artery sacrifice (median, 13; range, 9–15) during open surgical repair from June 1994 to December 2007 were reviewed retrospectively. Fifty-five patients (mean age, 65 ± 12 years; 46% were male), most with extensive Crawford type II thoracoabdominal aortic aneurysms, had a single procedure (single-stage group). Thirty-five patients (mean age, 62 ± 14 years; 57% were male) had 2 procedures (2-stage group), usually Crawford type III or IV repair after operation for Crawford type I descending thoracic aneurysm. The median interval between the 2-stage procedures was 5 years (3 months to 17 years). There were no significant differences between the groups with regard to age, gender, cause of the aneurysm, hypertension, chronic obstructive pulmonary disease, urgency, previous cerebrovascular accidents, year of procedure, or cerebrospinal fluid drainage. In single-stage procedures, hypothermic circulatory arrest was used in 24% of patients, left-sided heart bypass was used in 40% of patients, and partial cardiopulmonary bypass was used in 27% of patients. Somatosensory-evoked potentials were monitored in all patients, and motor-evoked potentials were monitored in 39% of patients. Cerebrospinal fluid was drained in 84% of patients.

Results: Overall hospital mortality was 11.1%. There were no significant differences in mortality, stroke, postoperative bleeding, infection, renal failure, or pulmonary insufficiency between the groups. However, 15% of patients in the single-stage group had permanent spinal cord injury versus none in the 2-stage group ($P = .02$). The significantly lower rate of paraplegia and paraparesis in the 2-stage group occurred despite a significantly higher number of segmental arteries sacrificed in this group: a median of 14 (11–15) versus 12 (9–15) ($P < .0001$).

Conclusion: A staged approach to extensive thoracoabdominal aortic aneurysm repair may reduce the incidence of spinal cord injury. This is of particular importance in designing strategies involving hybrid or entirely endovascular procedures. (J Thorac Cardiovasc Surg 2010;139:1464-72)

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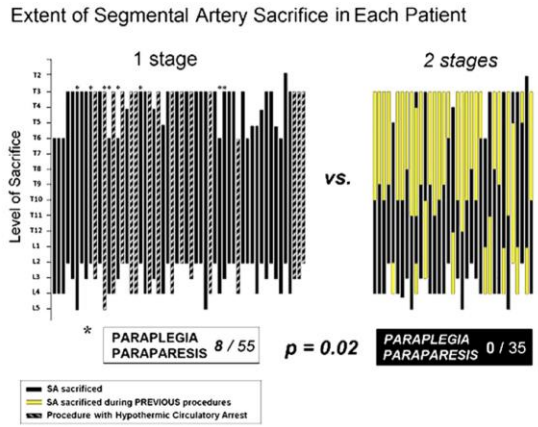
Surgery of the descending aorta has achieved remarkable success over the last 40 years. Aortic diseases that threaten catastrophic consequences, such as rupture or dissection, can now be treated with durable operations that have a low operative mortality.[1-3] Paraplegia remains the most devastating complication after repair of extensive descending thoracic and thoracoabdominal aneurysms (TAAA), whether by open surgical repair or endovascular strategies.[4-6] A number of adjuncts have been successfully used intraoperatively and postoperatively to minimize both spinal cord ischemia during surgery and the consequences of a precaution spinal cord blood supply postoperatively, and the incidence of paraplegia and paraparesis at centers for aneurysm repair has been decreasing.[7,8,15] Strategies to prevent ischemic spinal cord damage after extensive segmental artery (SA) sacrifice—or occlusion, essential for endovascular repair—are still evolving.

The current retrospective study concerns 90 patients with extensive SA sacrifice (≥9 SAs) during the course of aneurysm surgery. 55 of whom had a single-stage operation (Crawford II) and 35 of whom had a 2-stage operation. This study evaluates whether extensive SA loss in a 2-stage approach results in a decreased incidence of spinal cord injury compared with an equivalent SA loss in a single-stage approach.



Etz CD et al. J Thorac Cardiovasc Surg 2010

Endo TAAA repair

From the Society for Vascular Surgery

Staged endovascular repair of thoracoabdominal aortic aneurysms limits incidence and severity of spinal cord ischemia

Adrian O'Callaghan, MD, Tara M. Mastracci, MD, and Matthew J. Eagleton, MD, *Cleveland, Ohio*

Objective: Neurologic dysfunction remains a persistent complication of extensive aortic repair owing to disruption of the spinal collateral network. We hypothesized that staged repair might mitigate the incidence and severity of this spinal cord ischemia (SCI).

Methods: We conducted a retrospective cohort study of patients undergoing a Crawford type II repair of a thoracoabdominal aortic aneurysm between January 2008 and July 2013. Baseline demographics, incidence of prior aortic surgery, comorbidities, and outcomes were prospectively recorded. Staged repair was defined as intentional completion of the endovascular repair as two temporally separate procedures, referred to as a two-stage repair. Extent of aortic cover was calculated by three-dimensional imaging and reported as the proportion of the aorta covered between the left subclavian artery and the aortic bifurcation. Primary outcome measures were incidence and severity of SCI and mortality.

Results: The study included 87 patients, divided into the following subgroups: single-stage repair (n = 32; repair in a single procedure, without prior aortic surgery), two-stage repair (n = 27; repair in two separate procedures, without prior aortic surgery), and unintentionally staged repair (n = 28; those with prior aortic surgery, without an intention to stage). Median time between stages was 5 months (range, 1-60 months). All groups were equivalent in terms of demographics and risk factors; however, the staged group had significantly greater proximal aortic cover ($P = .001$). The overall rates of SCI in the nonstaged and staged groups were 37.5% (12 of 32) and 11.1% (3 of 27), respectively ($P = .03$). Furthermore, all neurologic injuries in the staged group were temporary. The 30-day survival in the single-stage, two-stage, and unintentionally staged repairs was 18.8%, 0%, and 10.7%, respectively ($P = .52$).

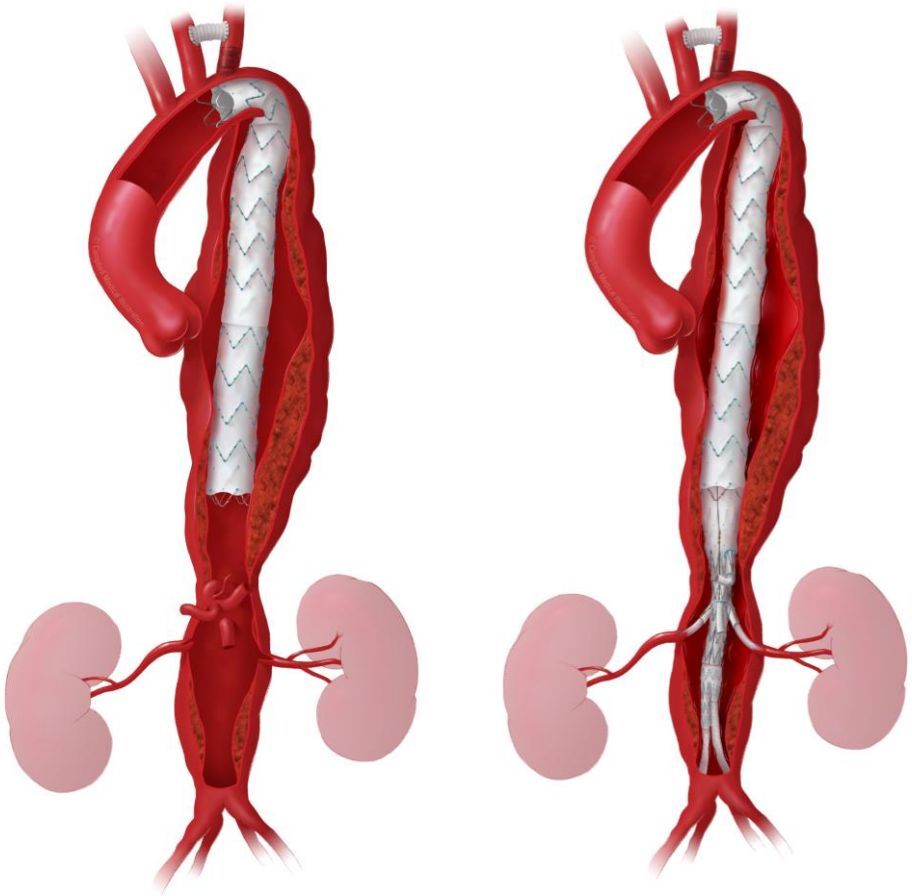
Conclusions: Staged repair appears both to protect against SCI and to enhance overall survival in extensive aortic repair. (J Vasc Surg 2015;61:347-54.)

Open surgical thoracoabdominal aortic aneurysm (TAAA) repair often patients a durable solution for this devastating disease, provided they can tolerate the morbid procedure. Initial reports of the successful repair of TAAA were soon followed by the recognition that such extensive surgery was associated with an increased incidence of postoperative neurologic dysfunction.[1-3] Over time, the development of protective measures, such as moderate hypothermia, distal bypass, and spinal drainage, mitigated these effects in part. However, maintenance of spinal perfusion, in the form of intercostal reimplantation, has been shown to be a powerful determinant of a positive outcome.[4-6]

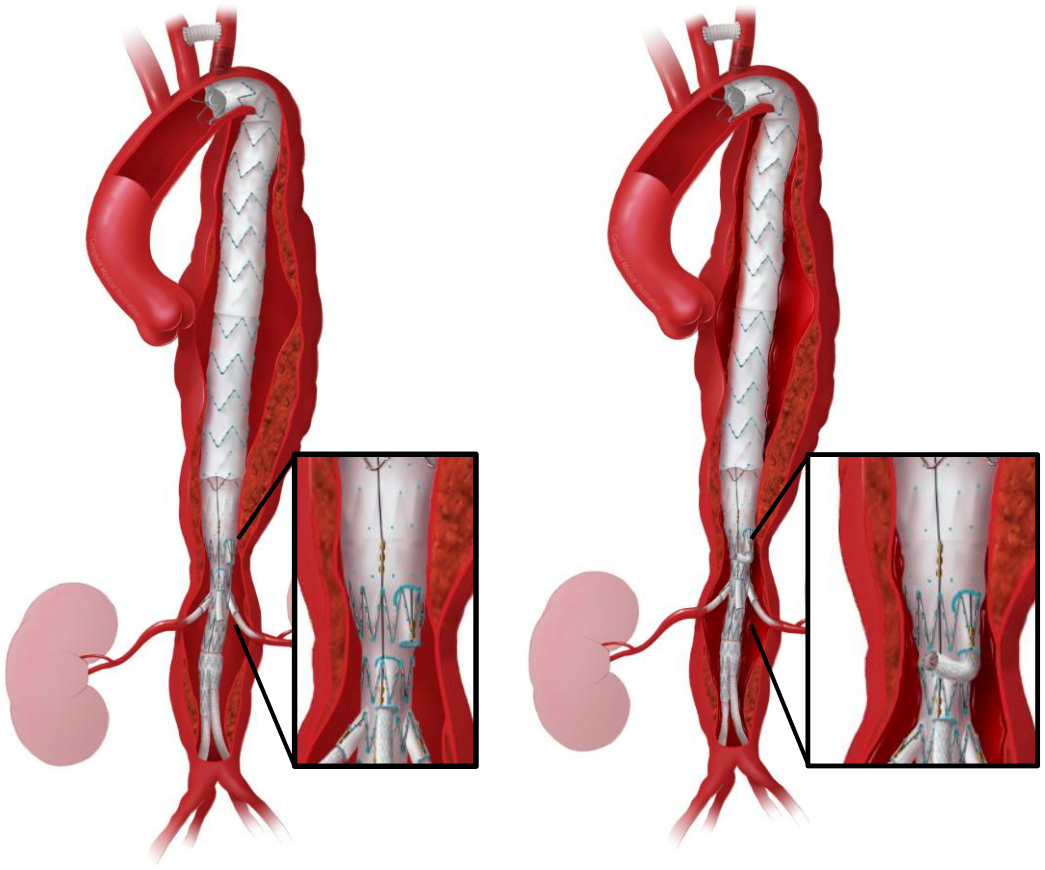
Endovascular repair of TAAA affords high-risk patients a therapeutic solution.[7] The absence of aortic cross-clamping and the avoidance of a thoracotomy, among other benefits, conspire to lessen the insult associated with open repair. However, despite these advances, the incidence of postoperative neurologic dysfunction remains stubbornly high. Rates of spinal cord ischemia (SCI) after endovascular repair of TAAA have been reported as high as 20%.[8] Device length, extent of aneurysm repaired, and occlusion of spinal collaterals such as the left subclavian artery or hypogastric artery were shown to be important contributors to the development of postoperative spinal dysfunction and clinical outcomes.[9,10] In spite of the many benefits of endovascular surgery, options are limited with regard to maintenance of perfusion of any excluded intercostal or lumbar vessels. A combination of clinical and experimental work in the last decade has served to further elucidate the spinal perfusion network and the relative importance of the different contributors. What has emerged is the concept of a collateral network that can potentially lessen the impact of spinal ischemia if it is optimized.[11] This collateral network may behave in a compensatory manner, similar to other vascular beds, and maintain perfusion pressures when contributors are excluded. Separating the ischemic insult into two lesser procedures may facilitate the ischemic insult into two lesser to compensate and to maintain function. We hypothesized that staging of extensive thoracoabdominal repairs in this

O'Callaghan A et al. J Vasc Surg 2015

Two steps staging protocols: TEVAR first / TASP



Proximal stent-grafting

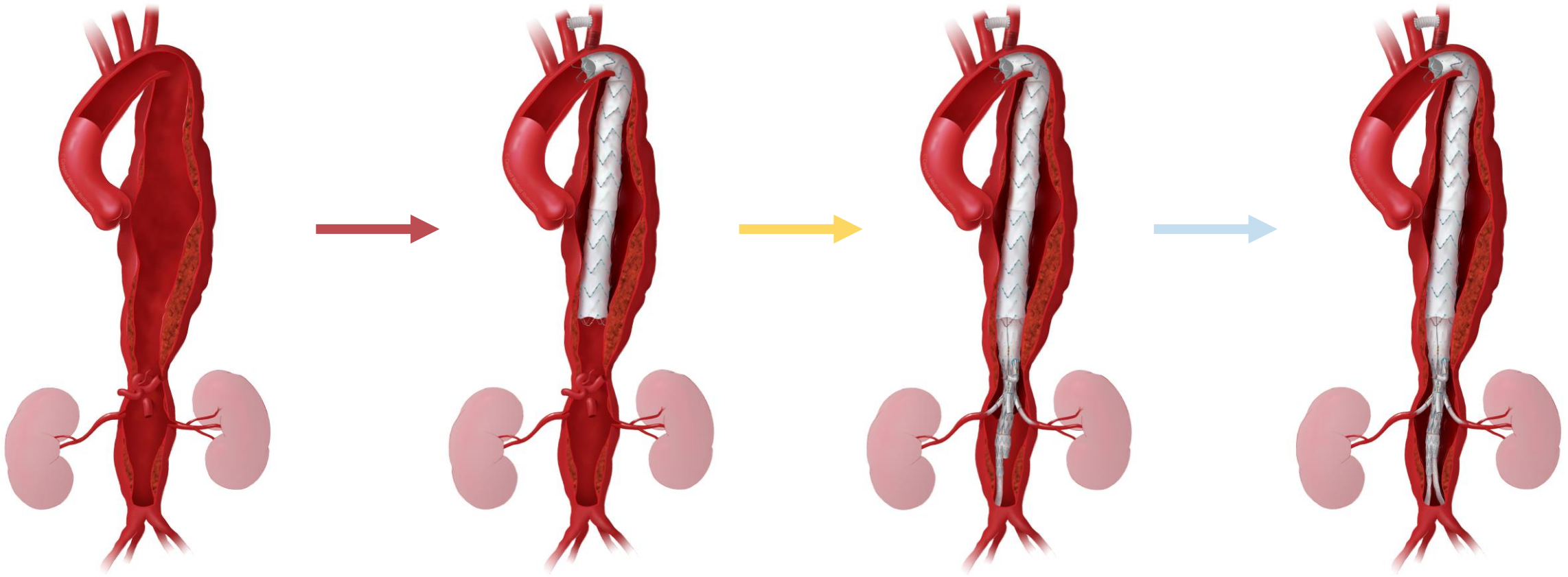


Temporary Aneurysm sac perfusion (TASP)

O'Callaghan A et al. J Vasc Surg 2015

Harrison SC et al. J Vasc Surg 2012

Three-step staged protocol



Type II TAAA

Thoracic step

Visceral step

Limb step

OSPEDALE SAN RAFFAELE

Bertoglio et al. Eur J Endovasc Surg 2020

Only therapeutic CSFD drainage in elective cases

- No prophylactic / preoperative CSFD
- Only therapeutic / postoperative CSFD
- Automated drainage

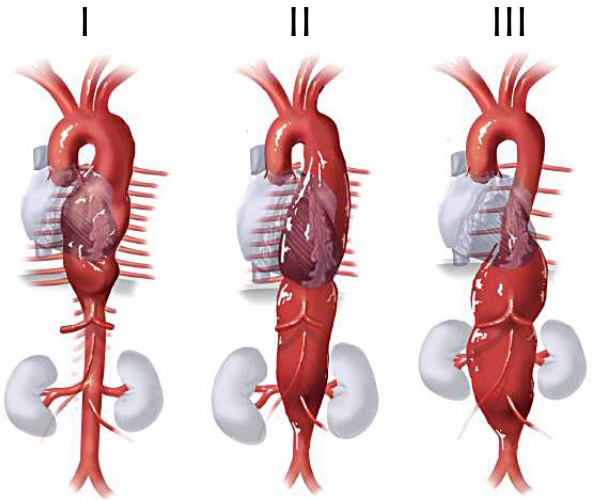
Liquogard Monitoring: < 10 cmH_2O; max flow 20 mL/h

Updated Type I-II-III TAAA elective experience

137 cases (Jan. 2013 – December 2021)

Age (years)	73 (IQR 68 – 78)
Male	72%
Hypertension	92%
Smoking	74%
Hyperlipemia	64%
Diabetes	12%
CAD ≥ 1 (SVS/AAVS)	**56%**
COPD ≥ 1 (SVS/AAVS)	**75%**
Renal ≥ 1 (SVS/AAVS)	**47%**
Renal stage ≥ II	**86%**
II (GFR 60-89 mL/min)	39%
III (GFR 30-59 mL/min)	43%
IV (GFR 15-29 mL/min)	5%
V (GFR < 15 mL/min)	4%

Crawford Classification



20 (15%) | 62 (45%) | 55 (40%)

Mean diameter: 61 (IQR 55-68)
Post-dissecting= 33 (24%)

Mortality / Spinal cord ischemia results

Mortality 7.3% - Permanent paraplegia 3.6%

Outcome	Type I (n=20)	Type II (n=62)	Type III (n=55)	Overall (n=137)
In-hospital mortality	2	1	3	**6 (4.4%)**
Intersurgical death*	1	3	0	**4 (2.9%)**
Permanent SCI	0	3	2	**5 (3.6%)**
Temporary SCI	4	10	5	**19 (13.9%)**

*All aneurysms > 8 cm: 3 ruptures and 3/4 CMD devices

Literature waiting time rupture / death

During the waiting time of CMDs

CLINICAL RESEARCH STUDIES

From the Society for Vascular Surgery

The risk of aneurysm rupture and target visceral vessel occlusion during the lead period of custom-made fenestrated/branched endograft

Enrico Gallitto, MD, PhD, Gianluca Faggioli, MD, Paolo Spath, MD, Rodolfo Pini, MD, Chiara Mascoli, MD, Stefano Ancetti, MD, Andrea Stella, MD, Mohammhed Abualhin, MD, and Mauro Gargiulo, MD, Bologna, Italy

ABSTRACT

Objective: The objective of this study was to evaluate adverse events occurring during the lead period of custom-made fenestrated/branched endograft for juxtarenal/pararenal abdominal aortic aneurysm (j/p-AAA) and thoracoabdominal aortic aneurysm (TAAA).

Methods: Between 2008 and 2017, patients enrolled for custom-made fenestrated/branched endograft repair were prospectively collected. Anatomic, procedural, and postoperative data were retrospectively analyzed. Lead period was defined as the time between the endograft order to the manufacturer and implantation. Aneurysm diameter, target visceral vessel (TVV) severe stenosis (>75% of estal lumen) and number of planned TVVs were evaluated at preoperative computed tomography angiography. Patency of TVVs was evaluated intraoperatively. Aneurysm rupture and TVV occlusion during the lead period were assessed.

Results: There were 141 custom-made fenestrated/branched endograft repairs planned. Of these, 133 patients (male, 87%; age, 73 ± 6 years) with complete available data were considered for the study. There were 75 (56%) j/p-AAAs and 58 (44%) TAAAs. The mean aneurysm diameter was 58 ± 6 mm (j/p-AAA, 56 ± 6 mm; TAAA, 61 ± 8 mm). 15 cases (11%) had >70-mm diameter. Planned TVVs were 431 (mean, 3 ± 1 TVVs/patient). The mean lead period was 89 ± 25 days, with five (3.8%) aneurysm ruptures (j/p-AAA, one; TAAA, four) occurring, two (1.5%) during manufacture and three (2.3%) with endograft available in the hospital; all three procedures were postponed because of cardiac or pulmonary comorbidities. In one TAAA rupture, the endograft was successfully implanted and the patient survived. Four of five ruptures had >70-mm diameter. On univariate analysis, chronic obstructive pulmonary disease (P = .01; odds ratio [OR], 4.40; 95% confidence interval [CI], 2.1-3.2) and aneurysm diameter >70 mm (P = .001; OR, 42; 95% CI, 4.3-408) were risk factors for aneurysm rupture during the lead period. With aneurysm diameter >70 mm being confirmed as an independent risk factor on multivariate analysis (P = .005; OR, 29.3; 95% CI, 2.8-306). Overall, eight endografts (6%) were not implanted/refused; two aneurysm rupture. Four death not related to aneurysm, two) In the remaining 125 patients (94%), 405 TVVs were planned. Of them, 46 (11%) had severe stenosis at preoperative computed tomography angiography. Twelve (3%) TVVs occluded in the lead period (renal arteries, five; celiac trunks, seven); six were recanalized and six were abandoned. Severe preoperative stenosis was a risk factor for TVV occlusion during the lead period (P = .002; OR, 13; 95% CI, 1.1-16).

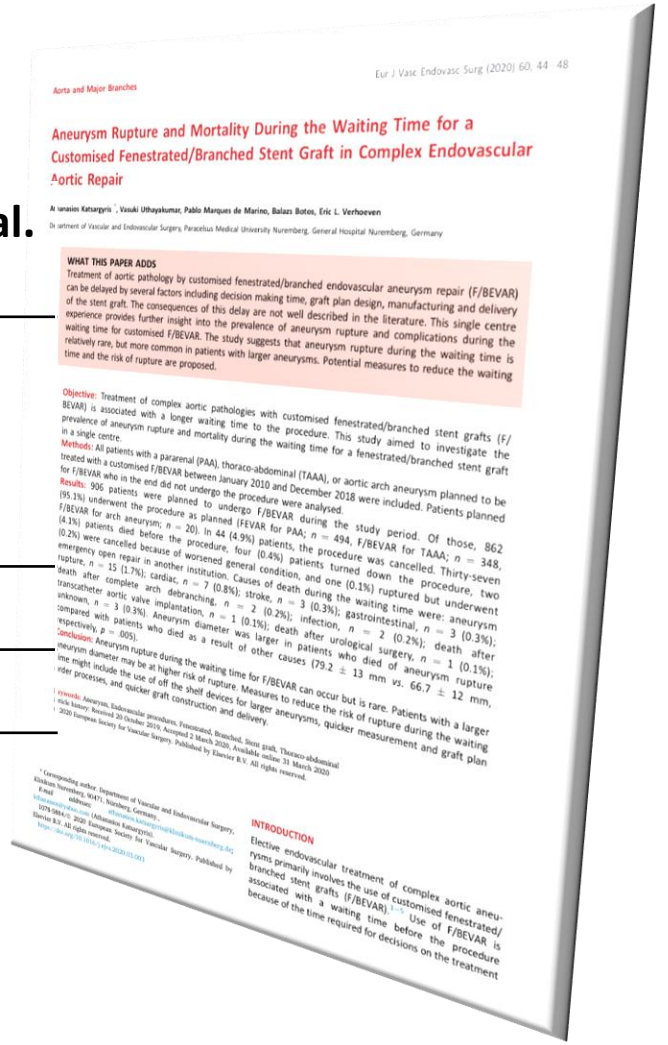
Conclusions: In our series, custom-made design required a mean lead period of 89 days, which was determined by both manufacturing time and clinical reasons. During this delay, there is a high risk of both rupture in aneurysms >70 mm and TVV occlusion in severely stanosed vessels. These factors should be considered in the indication for custom-made fenestrated/branched endograft repair. (J Vasc Surg 2020;71:16-24.)

Keywords: Juxtarenal abdominal aortic aneurysm; Pararenal aortic aneurysm; Thoracoabdominal aortic aneurysm; Fenestrated endograft; Target visceral vessels; Custom-made endograft

Fenestrated and branched endografts are safe and effective options in the treatment of aortic aneurysms involving the origin of renal and splanchnic arteries, as demonstrated by early and midterm results.[1-4] They are customized and patient specific endovascular devices used to treat patients with aortic aneurysms unfit for standard endovascular repair and at high risk for open surgery.

According to previous reports,customization of a patient-specific custom-made fenestrated/branched endograft...

Gallitto et al. (n=141)		Katsargyris et al. (n=906)
5 (3.8%)	Ruptures	16 (1.8%)
2 (1.4%)	Un-related death	22 (2.4%)
2 (1.4%)	Patients / clinical refusal	6 (0.6%)
6 (5.2%)	**Any intersurgical death**	**38 (4.2%)**



Aorta and Major Branches

Eur J Vasc Endovasc Surg (2020) 60, 44 - 48

Aneurysm Rupture and Mortality During the Waiting Time for a Customised Fenestrated/Branched Stent Graft in Complex Endovascular Aortic Repair

WHAT THIS PAPER ADDS

Treatment of aortic pathology by customised fenestrated/branched endovascular aneurysm repair (F/BEVAR) can be delayed by several factors including decision making time, graft plan design, manufacturing and delivery of the stent graft. The consequences of this delay are not well described in the literature. This single centre experience provides further insight into the prevalence of aneurysm rupture and complications during the waiting time for customised F/BEVAR. The study suggests that aneurysm rupture during the waiting time is relatively rare, but more common in patients with larger aneurysms. Potential measures to reduce the waiting time and the risk of rupture are proposed.

Gallitto et al. J Vasc Surg 2020

Katsargyris et al. Eur J Endovasc Surg 2020

Literature waiting time rupture / death

During the waiting time of CMDs

CLINICAL RESEARCH STUDIES

From the Society for Vascular Surgery

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Enrico Gallitto, MD, PhD, Gianluca Faggioli, MD, Paolo Spath, MD, Rodolfo Pini, MD, Chiara Mascoli, MD, Stefano Ancetti, MD, Andrea Stella, MD, Mohammhed Abualhin, MD, and Mauro Gargiulo, MD, Bologna, Italy

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Conclusions: In our series, custom-made design required a mean lead period of 89 days, which was determined by both manufacturing time and clinical reasons. During this delay, there is a high risk of both rupture in aneurysms >70 mm and TVV occlusion in severely stenosed vessels. These factors should be considered in the indication for custom-made fenestrated/branched endograft repair. (J Vasc Surg 2020;71:16-24.)

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Fenestrated and branched endografts are safe and effective options in the treatment of aortic aneurysms involving the origin of renal and splanchnic arteries, as demonstrated by early and midterm results.[1-3] They are customized and patient specific endovascular devices used to treat patients with aortic aneurysms unfit for standard endovascular repair and at high risk for open surgery.

According to previous reports,customization of a patient-specific custom-made fenestrated/branched endograft...

"…diameter may be at higher risk of rupture. Measures to reduce the risk of rupture during the waiting time might include the use of **off the shelf devices for larger aneurysms**. "

"…there is a **high risk** of both rupture in **aneurysms >70 mm** ... These factors should be considered in the indication for custom-madefenestrated/branched endograft repair."

Eur J Vasc Endovasc Surg (2020) 60, 44 - 48

Aorta and Major Branches

Aneurysm Rupture and Mortality During the Waiting Time for a Customised Fenestrated/Branched Stent Graft in Complex Endovascular Aortic Repair

Athanasios Katsargyris *, Vasuki Uthayakumar, Pablo Marques de Marino, Balazs Botos, Eric L. Verhoeven

Department of Vascular and Endovascular Surgery, Paracelsus Medical University Nuremberg, General Hospital Nuremberg, Germany

WHAT THIS PAPER ADDS

Treatment of aortic pathology by customised fenestrated/branched endovascular aneurysm repair (F/BEVAR) can be delayed by several factors including decision making time, graft plan design, manufacturing and delivery of the stent graft. The consequences of this delay are not well described in the literature. This single centre experience provides further insight into the prevalence of aneurysm rupture and complications during the waiting time for customised F/BEVAR. The study suggests that aneurysm rupture during the waiting time is relatively rare, but more common in patients with larger aneurysms. Potential measures to reduce the waiting time and the risk of rupture are proposed.

Objective: Treatment of complex aortic pathologies with customised fenestrated/branched stent grafts (F/BEVAR) is associated with a longer waiting time to the procedure. This study aimed to investigate the prevalence of aneurysm rupture and mortality during the waiting time for a fenestrated/branched stent graft in a single centre.

Methods: All patients with a pararenal (PAA), thoraco-abdominal (TAAA), or aortic arch aneurysm planned to be treated with a customised F/BEVAR between January 2010 and December 2018 were included. Patients planned for F/BEVAR who in the end did not undergo the procedure were analysed.

Results: 906 patients were planned to undergo F/BEVAR during the study period. Of those, 862 (95.1%) underwent the procedure as planned (FEVAR for PAA; $n = 494$, F/BEVAR for TAAA; $n = 348$, F/BEVAR for arch aneurysm; $n = 20$). In 44 (4.9%) patients, the procedure was cancelled. Thirty-seven (4.1%) patients died before the procedure, four (0.4%) patients turned down the procedure, two (0.2%) were cancelled because of worsened general condition, and one (0.1%) ruptured but underwent emergency open repair in another institution. Causes of death during the waiting time were: aneurysm rupture, $n = 15$ (1.7%); cardiac, $n = 7$ (0.8%); stroke, $n = 3$ (0.3%); gastrointestinal, $n = 3$ (0.3%); death after complete arch debranching, $n = 2$ (0.2%); infection, $n = 2$ (0.2%); death after transcatheter aortic valve implantation, $n = 1$ (0.1%); death after urological surgery, $n = 1$ (0.1%); unknown, $n = 3$ (0.3%). Aneurysm diameter was larger in patients who died of aneurysm rupture compared with patients who died as a result of other causes (79.2 ± 13 mm *vs.* 66.7 ± 12 mm, respectively, $p = .005$).

Conclusion: Aneurysm rupture during the waiting time for F/BEVAR can occur but is rare. Patients with a larger aneurysm diameter may be at higher risk of rupture. Measures to reduce the risk of rupture during the waiting time might include the use of off the shelf devices for larger aneurysms, quicker measurement and graft plan order processes, and quicker graft construction and delivery.

Keywords: Aneurysm, Endovascular procedures, Fenestrated, Branched, Stent graft, Thoraco-abdominal

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INTRODUCTION

Elective endovascular treatment of complex aortic aneurysms primarily involves the use of customised fenestrated/branched stent grafts (F/BEVAR).[1-3] Use of F/BEVAR is associated with a waiting time before the procedure because of the time required for decisions on the treatment

Gallitto et al. J Vasc Surg 2020

Katsargyris et al. Eur J Endovasc Surg 2020

New off-the-shelf TAAA devices

58% of TAAAs are treatable within IFUs

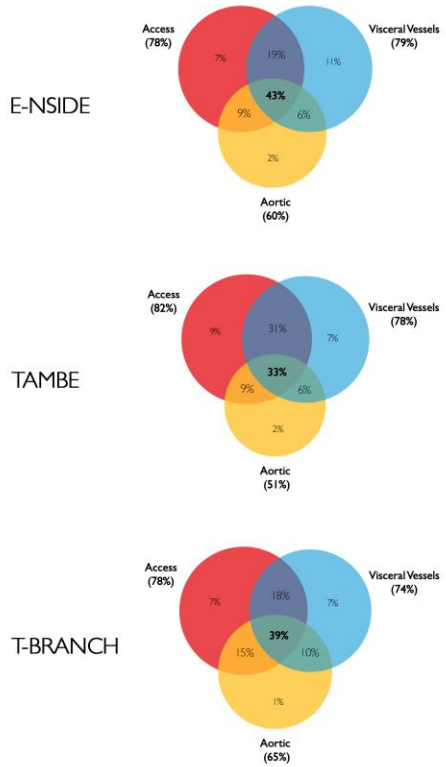
OFF-THE-SHELF MULTIBRANCHED STENT-GRAFT

E-NSIDE TAMBE T-BRANCH

OVERALL FEASIBILITY

E-NSIDE	43%
TAMBE	33%
T-BRANCH	39%

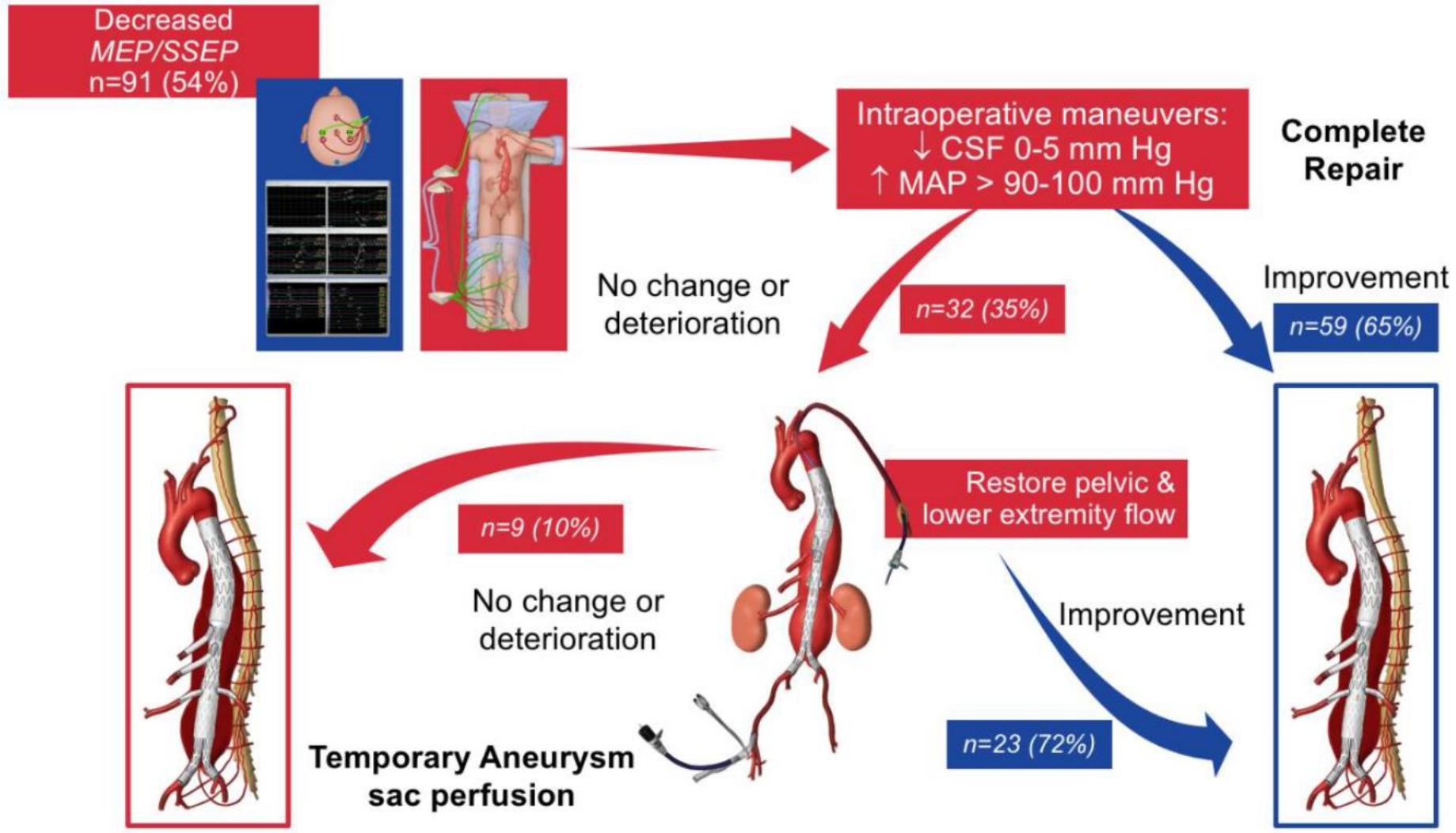
58% with all the three devices on the shelf



Bertoglio et al. J Vasc Surg 2021

Selective staged procedures based on MEP /SEPs

TEVAR first in 18% of the cases + selective TASP in 10% of the cases with 96% of CSFD



Banga et al. J Endovasc Ther 2016
Tenorio. Ann Surg 2021

Spinal cord postoperative possible triggers

No aneurysm exclusion during the more complex step

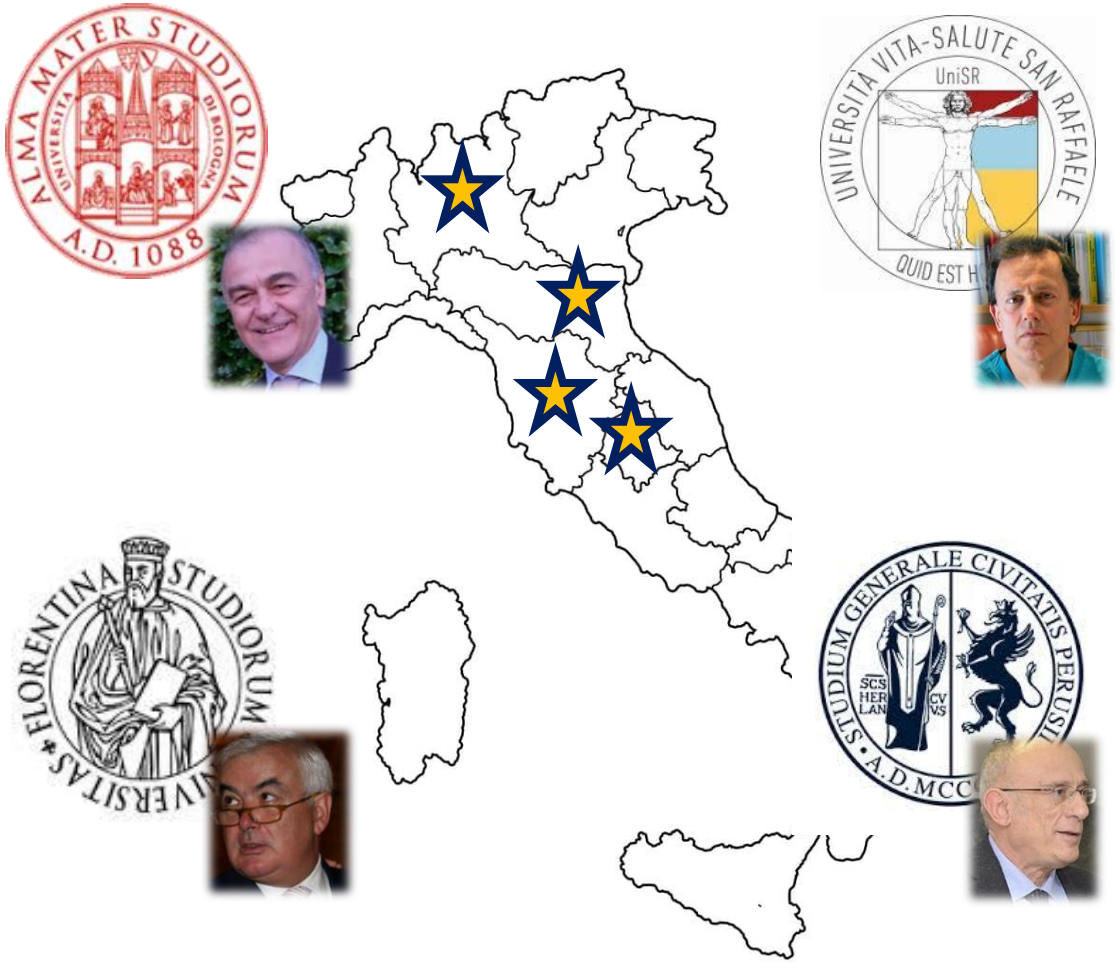
Final sac exclusion without precipitating SCI factors:

- Hypotensive state

- Anemia

- Cardiopulmonary complications

Identify high-risk patients subgroups requiring staging



	Overall (n=596)
TAAA	**252 (42%)**
Type I	32 (14%)
Type II	103 (45%)
Type III	96 (42%)
Type V	21 (8%)
Complex Abdominal	334 (56%)
Type IV	89 (27%)
JAAA	124 (37%)
Pararenal	121 (36%)
Visceral aortic patch	**10 (2%)**
Elective	**521 (86%)**
Urgent / Emergent	**75 (13%)**
Ruptured	16 (21%)
Symptomatic	11 (15%)
> 8 cm	48 (64%)

Bertoglio et al. J Vasc Surg 2021 (in press)

Journal of Vascular Surgery
SVS Society for Vascular Surgery

FULL LENGTH ARTICLE | ONLINE FIRST

Role of historical and procedural staging during elective fenestrated and branched endovascular treatment of extensive thoraco-abdominal aortic aneurysms

Luca Bertoglio, MD • Andrea Kahlberg, MD • Enrico Gallitto, MD • ... Mauro Gargiulo, MD • Roberto Chiesa, MD •

On behalf of the Italian Multicenter Fenestrated and Branched (IMF&B) study's group • Show all authors

Published: November 30, 2021 • DOI: https://doi.org/10.1016/j.jvs.2021.11.056

Cohort selection criteria (240 extensive TAAA)

INCLUSION

- Extensive TAAA (Crawford/Safi Type I, II, III and V)
- Elective

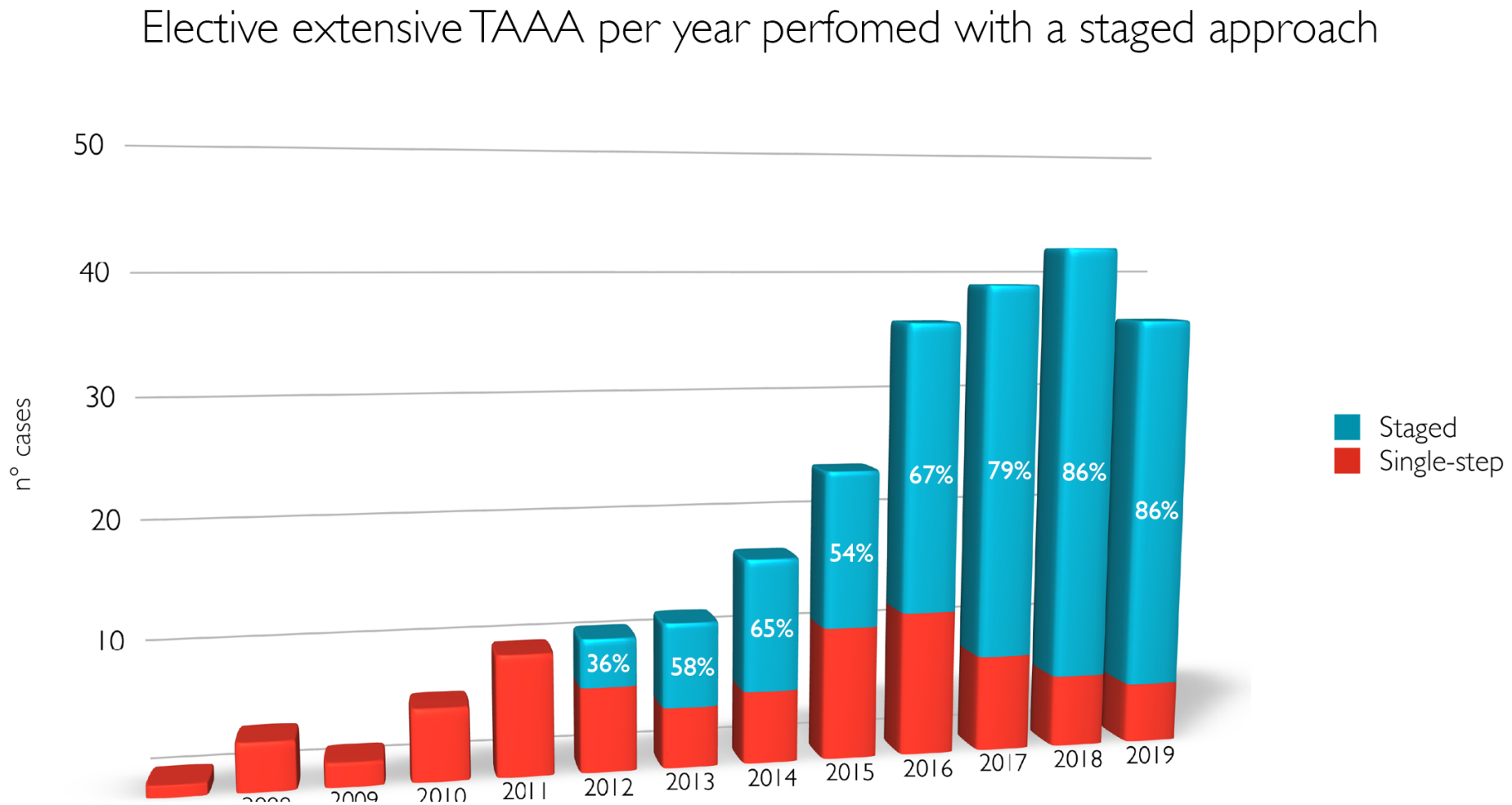
EXCLUSION

- Complex abdominal aneurysms (juxtarenal, pararenal and type IV)
- Ruptured
- Visceral aortic patch in previous TAAA open repair

Preoperative risk factors	Overall n=240
Age, years	73 (68-77)
Male	183 (76%)
Hypertension (grade ≥1)	232 (97%)
Smoking habit (grade ≥1)	171 (72%)
Diabetes (grade ≥1)	65 (27%)
Hyperlipidemia (grade ≥1)	155 (65%)
Renal status (grade ≥1)	82 (34%)
Pulmonary status (grade ≥1)	161 (67%)
Cardiac status (grade ≥1)	110 (46%)
Brain status (grade ≥1)	65 (27%)
SVS score, points	8 (6-12)
ASA score = 4	103 (43%)
Aneurysm diameter, mm	63 (58-70)
Post-dissecting	34 (14%)
Connective tissue disorders	8 (3%)

Grading according to SVS reporting standards

Cohort procedural staging: 136 (57%)



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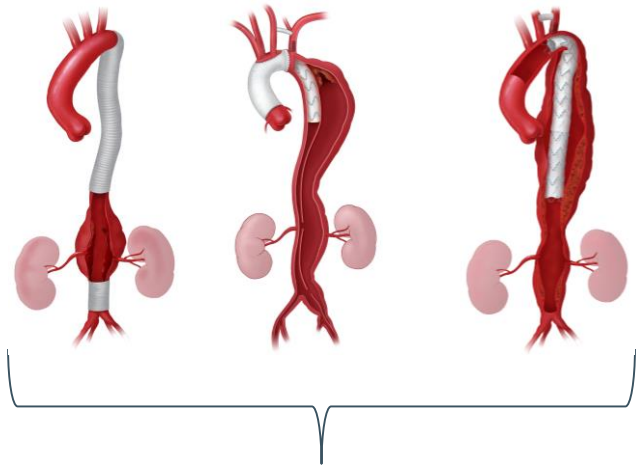
Previous aortic surgery = historical staging

Preoperative status	Overall n=240
LSA stenosis >75% or occlusion	**6 (3%)**
Any thoracic or abdominal aortic surgery	**136 (57%)**
Branched endovascular arch	1 (1%)
Frozen elephant trunk	9 (4%)
Thoracic endovascular repair	25 (10%)
Open thoracic repair	12 (5%)
Open thoraco-abdominal	13 (5%)
Open abdominal repair	89 (37%)
Abdominal endovascular repair	13 (5%)
Any HA stenosis >75% or occlusion	**37 (15%)**
Bilateral iliac occlusive disease	14 (6%)



EVAR
TEVAR
Open AAA
Open DTA
FET

Spinal cord ischemia: Uni- and Multivariable analysis

Only p values <.01

Outcome	Univariable analysis		Multivariable analysis		
	Risk factor	**P value**	**OR**	**95%CI**	**P value**
Spinal Cord complications Grade = 3 (Permanent)	Female gender	.051			
	Pulmonary status ≥1	.047			
	Previous thoracic or abdominal aortic repair	**.002**	**0.02**	**0.001 - 0.461**	**.014**
	Any LSA or HA stenosis>75% or occlusion	**.047**	**17.27**	**1.7 - 175.8**	**.016**
	Bilateral iliac occlusive disease	**.008**	**10.14**	**1.05-98.32**	**.046**
	Procedural staging	**.036**	**0.01**	**0.021 - 0.7**	**.019**
	Red blood cells transfusion visceral stage	**.021**	**1.37**	**1.07 - 1.76**	**.014**
	Any postop. renal complications	**<.001**	**6.49**	**1.20 - 35.0**	**.030**

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Procedural staging in historical staged patients

	No Historical staging n=104			Historical staging n=136		
	No Procedural Staging n=37	Procedural Staging n=67	p value	No Procedural Staging n=46	Procedural Staging n=90	p value
Hypertension (grade ≥1)				44 (96%)	90 (100%)	**.046**
Diabetes (grade ≥1)	9 (25%)	18 (27%)	**.050**			
Pulmonary status (grade ≥1)				27 (59%)	68 (76%)	**.043**
Brain status (grade ≥1)				7 (15%)	28 (32%)	**.041**
TAAA V extent	6 (16%)	3 (5%)	**.042**			
Any LSA or HA stenosis >75% or occlusion	3 (8%)	9 (13%)	.421	7 (15%)	24 (27%)	.134
Bilateral iliac occlusive disease	3 (8%)	6 (9%)	.931	2 (4%)	3 (6%)	.815
Any preoperative CSFD	18 (49%)	39 (60%)	.277	28 (61%)	45 (51%)	.280
Any Mortality	3 (8%)	5 (8%)	.906	3 (7%)	7 (8%)	.791
Any systemic complication ≥1	19 (51%)	27 (40%)	.277	24 (52%)	39 (43%)	.328
Any temporary or permanent SCI	9 (24%)	9 (13%)	.160	7 (15%)	15 (17%)	.828
Permanent grade 3 SCI	**7 (19%)**	**4 (6%)**	**.040**	**1 (2%)**	**1 (1%)**	**.626**
Cerebrovascular complications	1 (3%)	4 (6%)	.456	0%	5 (6%)	.103
Cardiac complications	4 (11%)	7 (10%)	.954	8 (17%)	13 (14%)	.653
Pulmonary complications	8 (22%)	13 (19%)	.787	15 (33%)	20 (22%)	.190
Renal complications	15 (41%)	17 (25%)	.109	10 (22%)	19 (21%)	.933
Bowel complications	1 (3%)	4 (6%)	.456	1 (2%)	2 (2%)	.986
Number of RBC transfusion	**1 (0-2)**	**2 (1-7)**	**.005**	**1 (0-4)**	**3 (0-5)**	**.071**

Procedural staging in historical staged patients

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Role of collateral network impairment

Impaired collateral network

Previous aortic surgery

	LSA or Hypogastric stenosis or occlusion n=43	Procedural staging n=157	n	Permanent Grade 3 SCI n=13
No Historical staging n=104	NO	NO	34	6 (18%)
		YES	58	2 (3%)
	YES	NO	3	1 (33%)
		YES	9	2 (22%)
Historical staging n= 136	NO	NO	39	0%
		YES	66	0%
	YES	NO	7	1 (14%)
		YES	24	1 (4%)

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Role of collateral network impairment

Impaired collateral network

Previous aortic surgery

	LSA or Hypogastric stenosis or occlusion n=43	Procedural staging n=157	n	Permanent Grade 3 SCI n=13
No Historical staging n=104	NO	NO	34	6 (18%)
		YES	58	2 (3%)
	YES	NO	3	1 (33%)
		YES	9	2 (22%)
Historical staging n= 136	NO	NO	39	0%
		YES	66	0%
	YES	NO	7	1 (14%)
		YES	24	1 (4%)

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Staged vs Multistaged (unpublished data)

157 patients

	Two stages		Three stages	*P value*
	+ TEVAR n=77	+ TASP n=45	+ TEVAR + TASP n=35	
Preoperative risk factors				
Diabetes	27 (35%)	4 (9%)	17 (49%)	**<.001**
ASA score = 4	26 (34%)	28 (62%)	9 (26%)	**.004**
TAAA I extent	20 (26%)	0%	5 (14%)	**.002**
Any aortic previous aortic surgery	50 (65%)	22 (49%)	18 (51%)	.413
Any preoperative CSFD	43 (56%)	33 (73%)	10 (29%)	**<.001**
30-day outcomes				
Clinical success	60 (78%)	32 (71%)	28 (80%)	.932
Any Mortality	6 (8%)	5 (11%)	1 (3%)	.768
In-hospital	4 (5%)	3 (7%)	0%	.693
Intersurgical	2 (3%)	2 (4%)	1 (3%)	.996
Any MAE $\geq$ 1	30 (39%)	23 (51%)	13 (37%)	.711
Any spinal cord ischemia	13 (17%)	6 (13%)	5 (14%)	.997
Permanent spinal cord deficit	2 (3%)	2 (4%)	1 (3%)	.996
Cerebrovascular complications	4 (5%)	3 (7%)	2 (7%)	.575
Cardiac complications	10 (13%)	5 (11%)	5 (14%)	.999
Pulmonary complications	14 (18%)	12 (27%)	7 (20%)	.898
Renal complications	12 (16%)	18 (40%)	6 (17%)	**.016**
Bowel complications	2 (3%)	2 (4%)	2 (6%)	.974
Number of RBPC transfusion	2 (0-4)	5 (2-10)	2 (1-5)	**.004**

Conclusions – How many Stages???

- Both historical and planned procedural staging were associated with a reduction of permanent SCI

- No additional benefit was observed when a procedural staging was performed in patients with historical staging and intact collateral network

- The number of stages should be influenced by the collateral network status and by the use of prophylactic CSFD use

Procedural staging in historical staged patients

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Few differences

Same collateral network and CSFD use