Hôpitaux de Toulouse

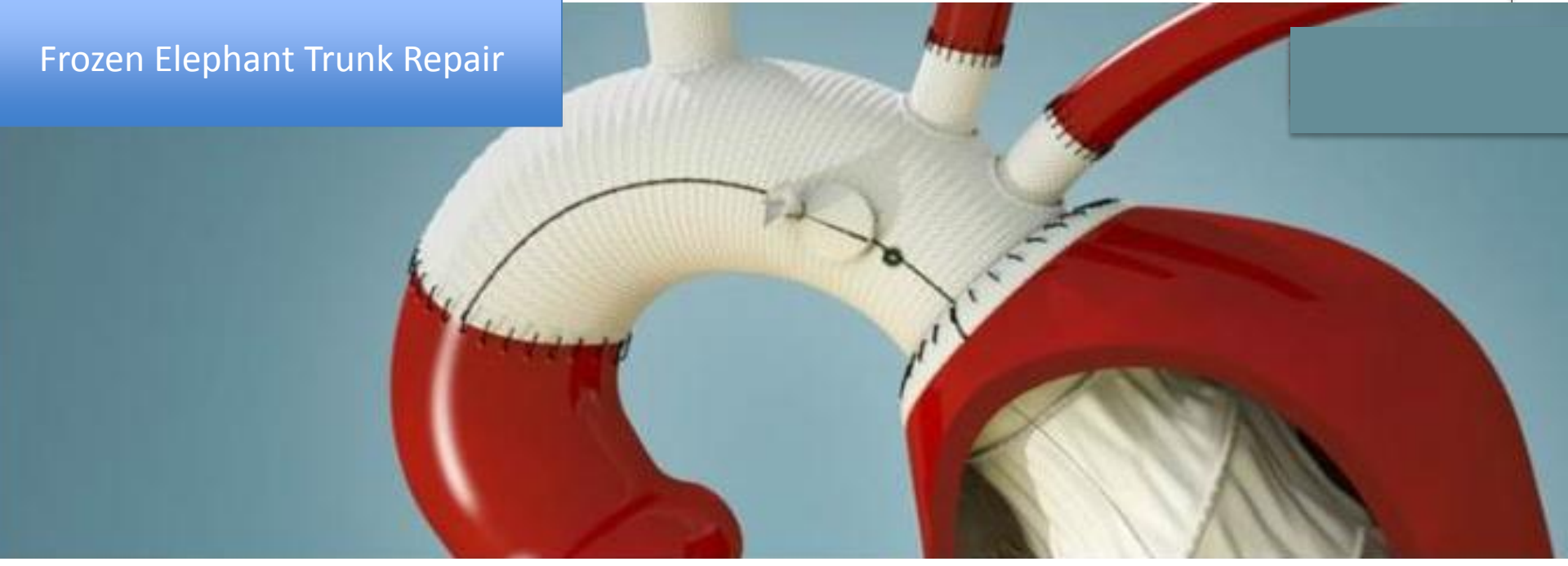
Université de Toulouse

Université Paul Sabatier TOULOUSE III

Arch and Elephant Trunk Open Repair

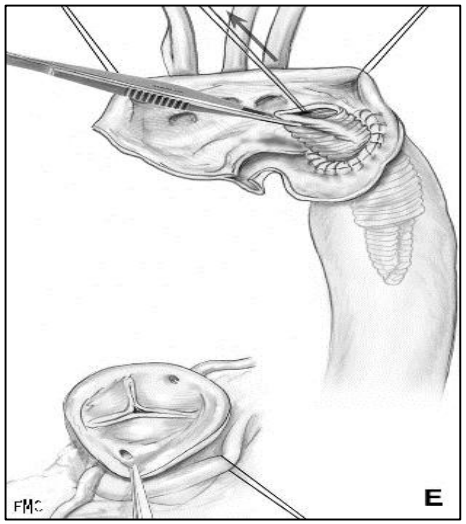
X Chaufour, E Grunenwald, *J Porterie,*
B Lebas, C Cron, Y Glock, B Marcheix

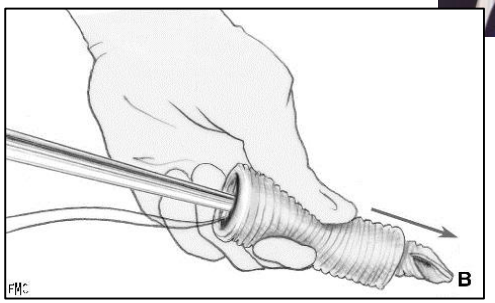
Frozen Elephant Trunk Repair

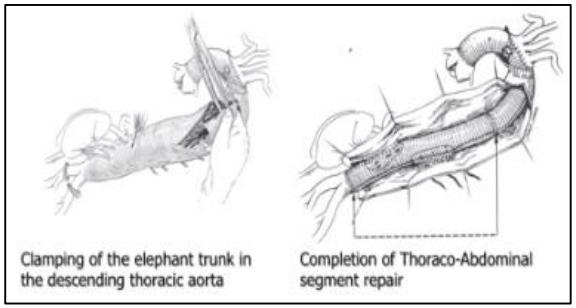


INTRODUCTION

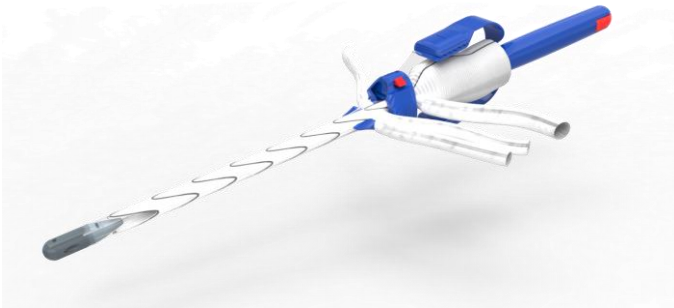
In March 1982, Dr. Hans-Georg Borst introduced the 2-stage elephant trunk technique in Hannover,







Frozen Elephant Trunk (FET) Technique



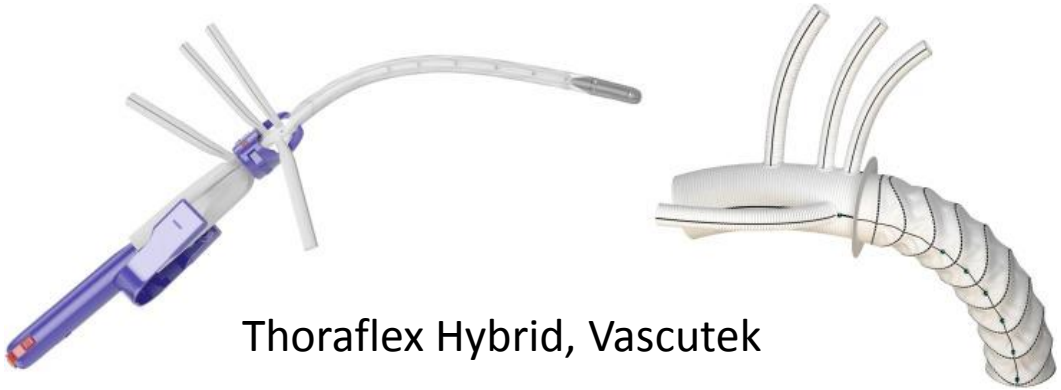
Experimental assessment of newly devised transcatheter stent-graft for aortic dissection. *Kato M, & al Circulation. 1996 Nov 1; 94(9 Suppl):II188-93.*

FET technique is gaining wider acceptance

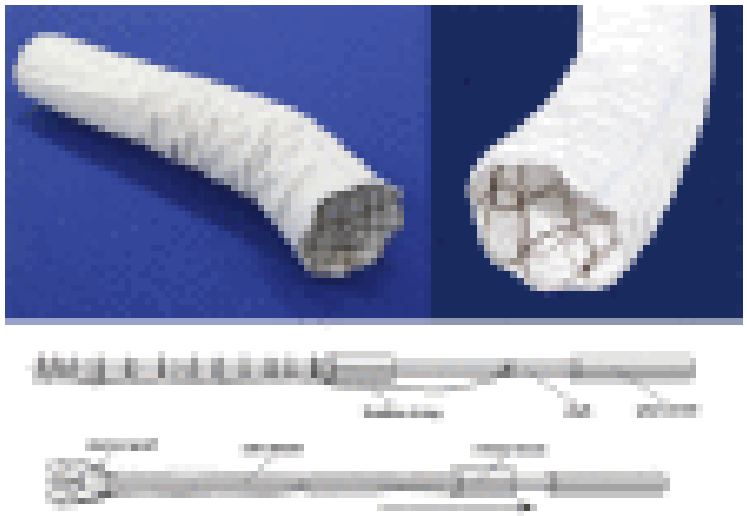
Comparison of currently available open stented grafts.

Device	E-vita Open (Plus)	Thoraflex Hybrid	Cronus	J Graft Open
Year of marketing	2008	2012	2003	2014
Manufacturer	Jotec	Vascutek	MicroPort	Japan Lifeline
Number of implants (by Dec 2015)	>5000	>1180	>18000	> 2200
Availability	Europe, Asia Pacific	Europe, Asia Pacific, Canada	China, South America	Japan
Technical Aspects				
Full length (cm)	18, 22, 23	34, 39	15-25	57
Diameter of stent graft (mm)	24-40	28-40	21-32	21-39
Length of stent graft (cm)	13, 15, 16	10, 15	4-15	6, 9, 12
Proximal and distal diameter	Same	Different	Same	Same
Stent design and material	Z shaped nitinol	Ring shaped nitinol	Z shaped conichrome	Oval shaped 2-layer nitinol
Arch curvature	Fair	Better	Fair	Possibly best
Sewing collar	Yes	Yes	No	No
Distal sewing cuff	No	No	1 cm	No
Unstented portion	Yes	Yes	No	Yes
Arch and perfusion branches	No	Yes	No	No
Delivery method	Squeeze and pull	Pull, press, pull	Pull	Pull
Need for positioning	Yes	No	No	Yes
Guidewire or X-Ray	Necessary	Optional	No need	No need
Blood permeability	60 mL/cm^2/min	NA	NA	150 mL/cm^2/min
Method of arch repair	Carrel patch technique	An integrated 4-branched graft	A separate 4-branched graft	A separate branched graft
Better indicated in	Aneurysm	Aneurysm and dissection	Dissection	Aneurysm

Available FET Devices

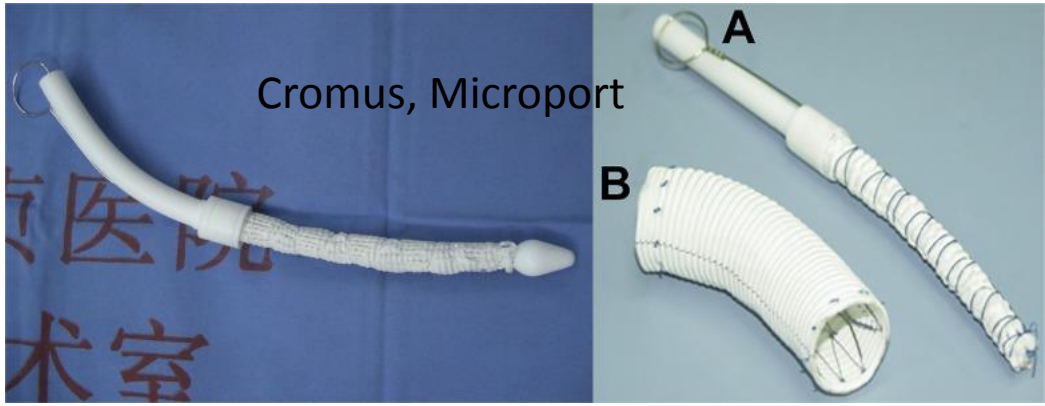


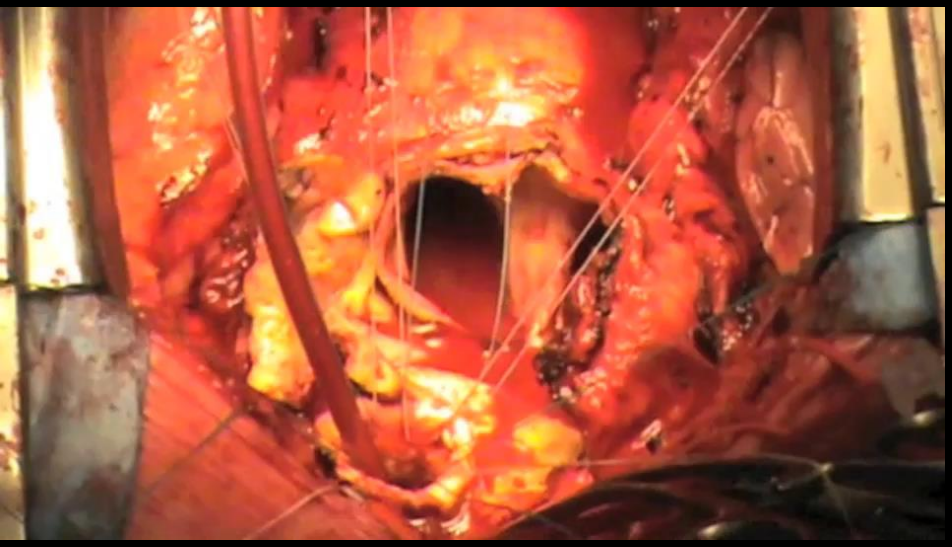
Thoraflex Hybrid, Vascutek

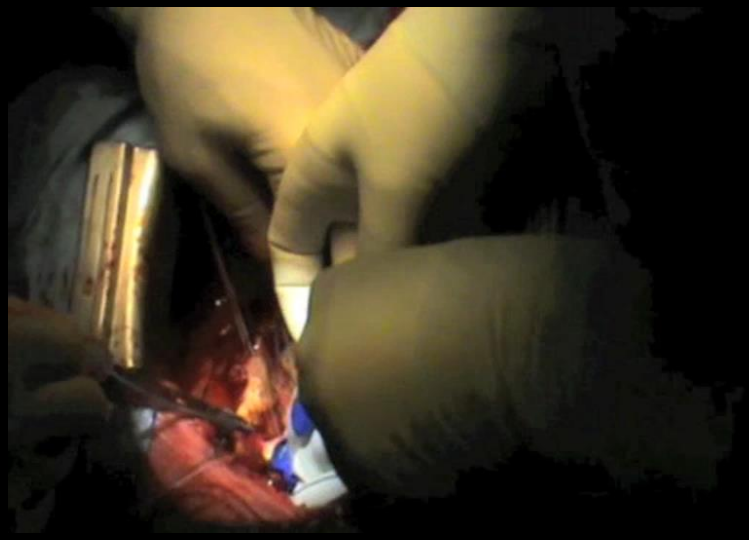


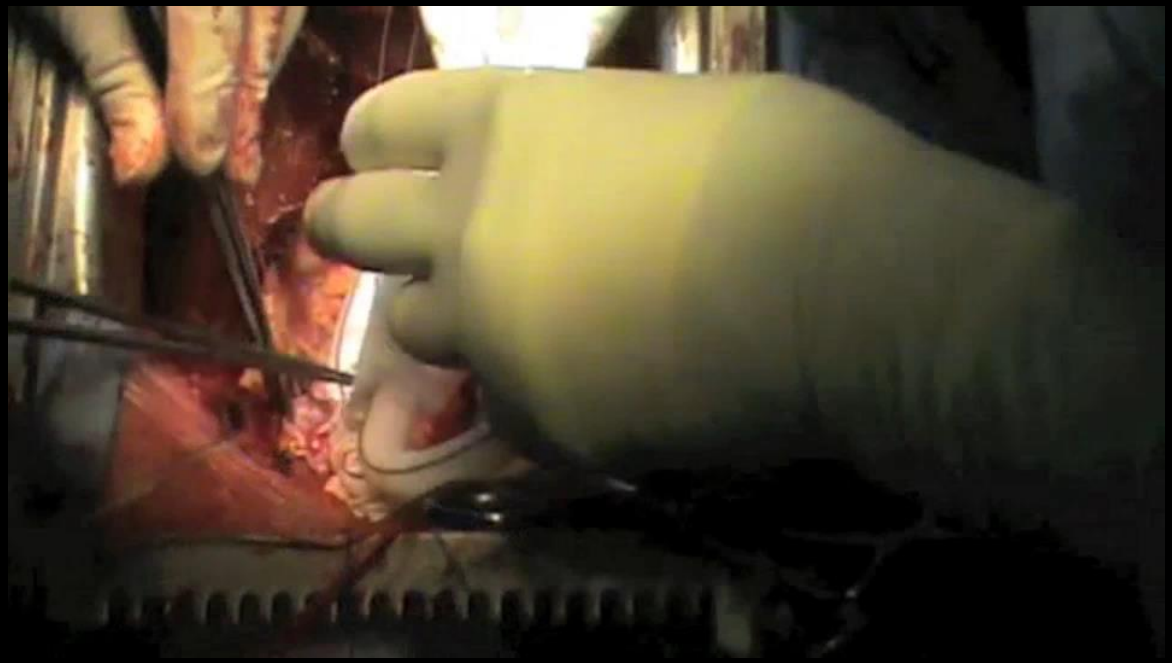
J Graft Open, Japan Lifeline

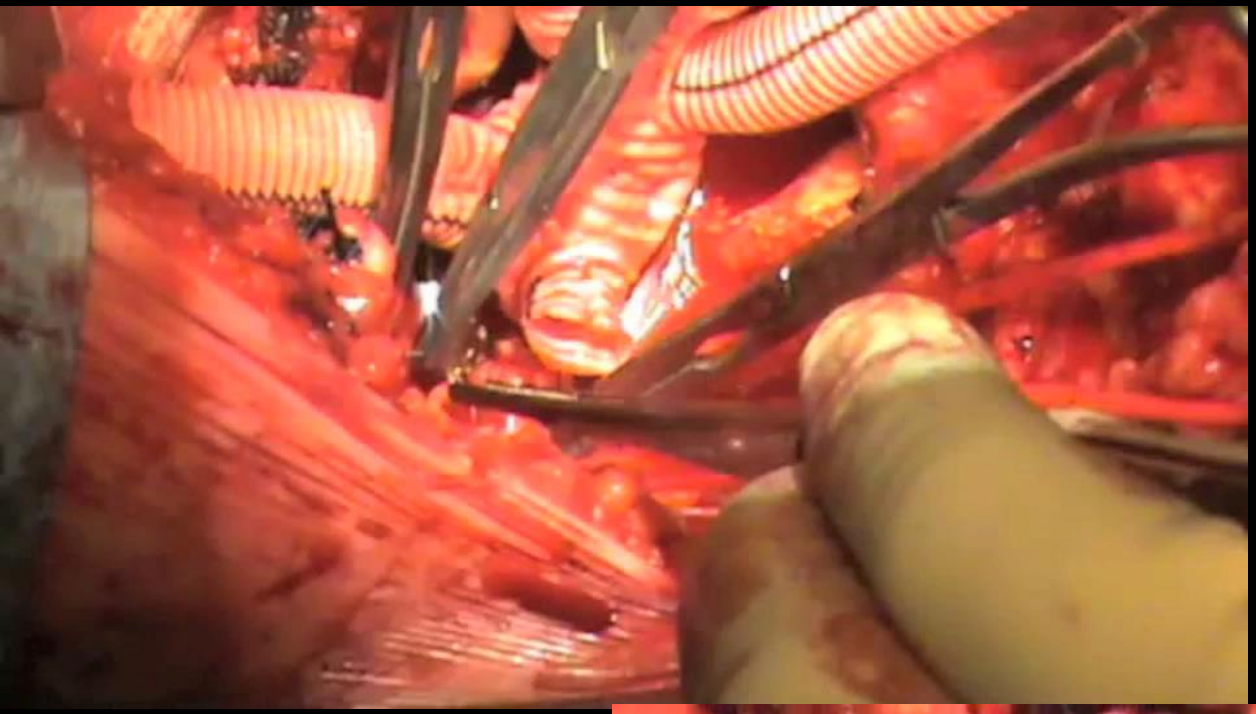
E-vita Open Plus, Jotec

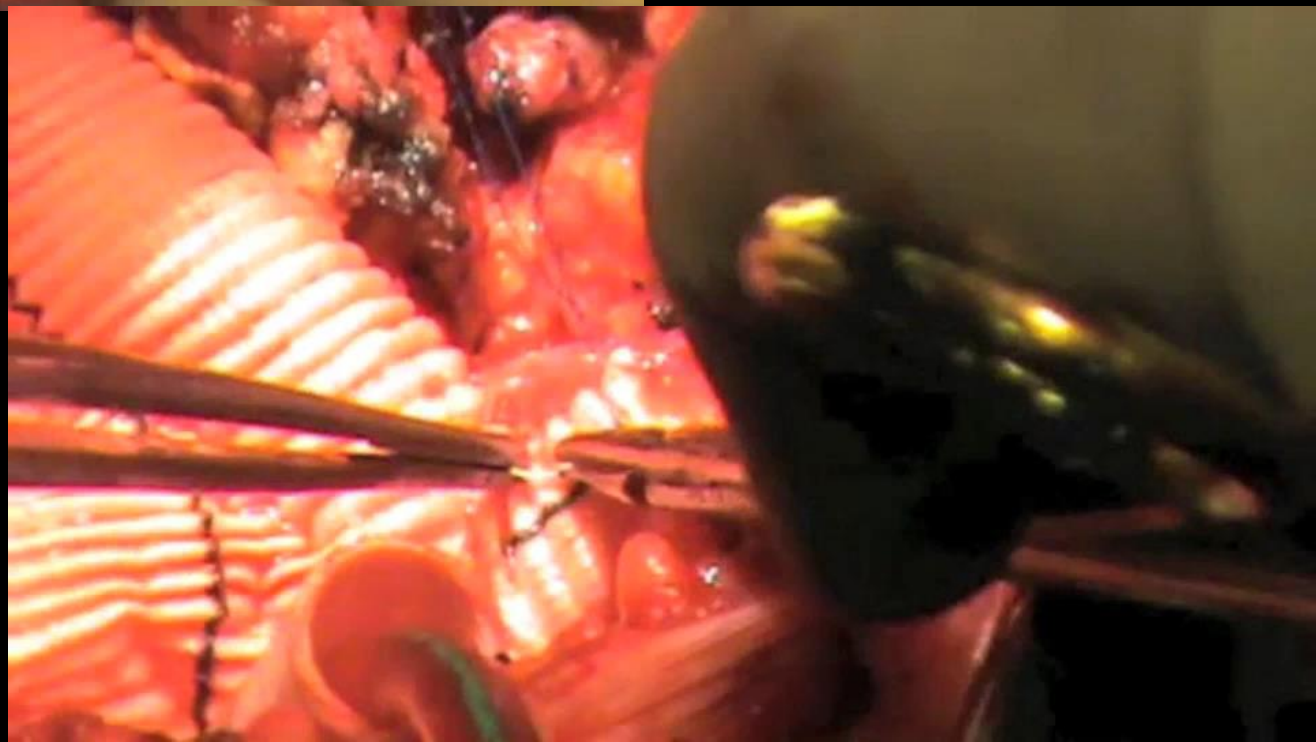












CHU Toulouse : 01/2014 – 04/2016

N patients	**35**
Ratio H/F	**27 / 8**
Age	**59,9**
Aneurysms	**10**
Acute Type A	**10**
Chronic Type B	**15**
Redoo	**11**
Aortic Root	**14**

- Right axillary artery canulation
- Moderate Hypothermia (25-28°C)
- Short circulatory arrest
- selective antegrade cerebral perfusion
- NIRS monitoring
- Continous retrograde cardioplegia

35 patients
Mortality: 8,5 %
Stroke: 5,2%
Spinal Cord Injury: 2,5%

Circulatory Arrest	**10,5**	**+/- 4,6**
Antegrade cerebral perfusion	**66,6**	**+/- 16,3**
Cross clamp	**119,7,**	**+/- 34,3**
Cardiopulmonary bypass,	**192,8**	**+/- 33,3**

Comparison of currently available open stented grafts.

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Blood permeability	60 mL/cm^2/min	NA	NA	150 mL/cm^2/min
Method of arch repair	Carrel patch technique	An integrated 4-branched graft	A separate 4-branched graft	A separate branched graft
Better indicated in	Aneurysm	Aneurysm and dissection	Dissection	Aneurysm
Clinical Outcomes				
Patient age (years)	61	59 ± 14	46 ± 11	72 ± 9
Cardiopulmonary bypass time	239	241 ± 61	193 ± 51	178 ± 40
Selective antegrade cerebral perfusion time	71	85 ± 39[*]	25 ± 9	40 ± 37
Early mortality (%)	15.8 (90/568)	8.7 (13/149)[#]	6.4 (53/832)	5.0 (3/60)
Early stroke (%)	2.6 (15/568)	8.0 (12/149)[#]	2.0 (17/832)	10.0 (6/60)
Early spinal cord injury (%)	3.5 (20/568)	4.0 (6/149)[#]	2.4 (20/832)	6.7 (4/60)
Duration of follow-up (year)	5	1[*]	5.0 ± 2.6	3.8
Late survival (%)	69-85	77 ± 7[*]	89	78
Late reintervention (%)	2-27	14.1 (24/149)[#]	6.5 (69/1063)	8.3 (5/60, 1 yr)

[#]Calculated based on the reports of Ius, Pichlmaier, Shrestha and Di Marco [

Review

Elephant trunk procedure 27 years after Borst: what remains and what is new?

Fabio Ius [a,b,*], Christian Hagl [b], Axel Haverich [b], Maximilian Pichlmaier [b]

European Journal of Cardio-thoracic Surgery 40 (2011) 1–12

Table 3. Frozen elephant trunk: case series and results.

Author	Year	Patients	Pathology	In-hospital mortality	Stroke (permanent or transient)	Spinal cord injury (permanent or transient)	Other neurologic dysfunction	Endoleaks
Mizuno [40]	2002	9	Dissections 9	1 (11.15%)	1 (11.15%)	2 (22%)	0	1 (11.15%)
Miyairi [41]	2002	19	Aneurysms 17, dissections 2	2 (10.5%)	0	4 (21.1%)	0	1 (5.26%)
Usui [42]	2002	24	Aneurysms 22, dissections 2	0	1 (4%)	4 (17%)	0	
Sueda [43]	2004	34	Aneurysms 34	2 (5.9%)	1 (2.9%)	1 (2.9%)	0	1 (2.9%)
Flores [44]	2006	25	Aneurysms 25	3 (12%)	4 (16%)	6 (24%)	2 (8%)	
Baraki [51]	2007	39	Dissections 21, aneurysms 18	5 (12.8%)	5 (12.8%)	0	5 (12.8%)	2/25 (8%)
Gorlitzer [52]	2007	7	Dissections 5, aneurysms 2	0	1 (14.2%)	0	0	1 (14.2%)
Shimamura [45]	2008	126	Dissections 57, aneurysms 69	7 (5.5%)	7 (5.6%)	8 (6.3%)	12 (9.5%)	5 (3.9%)
Midorikawa [46]	2008	7	Aneurysms 6, dissection 1	1 (14.2%)	0	1 (14.2%)	0	
Di Bartolomeo [53]	2009	34	Dissections 27, aneurysms 7	2 (6%)	0	3 (8.8%)	0	6 (17.6%)
Uchida [47]	2009	58	Aneurysms 58	1 (1.7%)				
Uchida [48]	2009	65	Dissections 65	3 (4.6%)				
Sun [49]	2009	107	Dissections 107	5 (4.67%				
Tsagakis [54]	2009	41	Dissections 35, aneurysms 6	3 (7%)				
Pochettino [55]	2009	36	Dissections 36	5 (14%)				
Shimamura [50]	2009	69	Aneurysms 36, dissections 33	5 (7.2%)				
Total		700	400 (57%) dissections	45 (6.4%)				

700 patients
Mortality: 6,4%
Stroke: 5 %
Spinal Cord: 5,6%

Systematic Review

A systematic review and meta-analysis on the safety an of the frozen elephant trunk technique in aortic arch sur

David H. Tian[1], Benjamin Wan[1], Marco Di Eusanio[1,2], Deborah Black[3], Tristan D. Yan[1,4]

[1]The Systematic Review Unit, Collaborative Research (CORE) Group, Sydney, Australia; [2]Cardiovascular Surgery Departmer Hospital, Bologna University, Bologna, Italy; [3]Faculty of Health Sciences, [4]Department of Cardiothoracic Surgery, Royal University of Sydney, Sydney, Australia

Corresponding to: Tristan D. Yan, Associate Professor. Department of Cardiothoracic Surgery, Royal Prince Alfred Hospita Sydney, Australia; The Collaborative Research (CORE) Group, Sydney, Australia. Email: tristanyan@annalscts.com.

Ann Cardiothorac Surg 2013;2(5):581-591

Table 3 Summary of clinical outcomes

First author	30-day mortality (%)	Stroke (%)	Spinal cord injury (%)	Renal failure (%)	Reoperation for bleeding (%)	Hospita stay (d		
Usui (8)	0	4.2	12.5	NR	NR	36±15		
Flores (9)	12.0†	16.0	24.0	NR	NR	NR		
Shimamura (10)	3.2	5.6	6.3	4.8	2.4	29[M]	81	63
Pochettino (11)	13.9†	2.8	8.3	16.7	NR	NR	NR	NR
Uchida (12)	3.8	2.6	1.9	5.1	2.6	NR	NR	NR
Chen (13)	0	10.7	NR	7.1	3.6	NR	NR	88
Sun (14)‡	1.4†	2.1	2.8	1.4	7.0	NR	NR	NR
Jakob (15)	12	5.8	8.0	21.9	13.9	19[M]	NR	74
Shi (16)	2.2	0	0	NR	4.3	19±6	NR	NR
Shen (17)	7.9†	0	5.3	NR	0	21±13	91	NR
Hoffman (6)	0	0	0	NR	12.5	19±8	NR	NR
Leontyev (18)	8.7	13.0	21.7	23.9	13.0	NR	70	68
Xiao (23)	18.2†	0	0	3.0	NR	26±11	NR	NR
Ius (19)	15.3	10.7	0.8	16.0	18.3	18±17	82	72
Sun (20)	7.8†	2.5	2.5	4.3	2.5	NR	NR	NR
Di Eusanio (21)	17.2	7.4	9.0	24.6	12.3	15[M]	97	NR
Roselli (22)	0	11.8	NR	5.9	NR	20±12	NR	NR
Minimum	0	0	0	0.7	0	15	70	63
Maximum	18.2	16.0	24.0	24.6	18.3	36	97	88
Weighted average	8.3	4.9	5.1	10.9	7.8	NA	84.7	71.5

†in-hospital mortality; ‡only chronic dissection cases; M, median; NA, not statistically available; NR, not reported

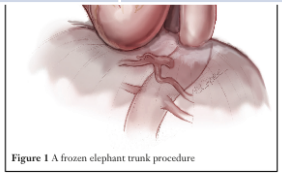


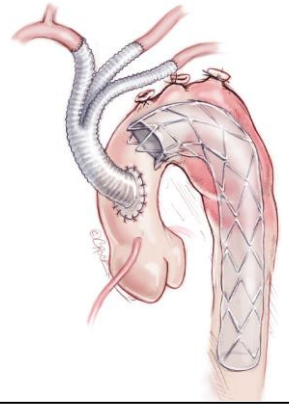
Figure 1 A frozen elephant trunk procedure

	16 studies, 1992 - 2009 ET procedure	16 studies, 2002 et 2009 FET procedure
Mortality	**1.8 à 20%**	**1.7 à 14.2%**
Stroke	**1.2 à 20%**	**2.8 à 14.2%**
Spinal Cord Injury	**0.4 à 8.1%**	**2.8 à 14.2%**
Endoleak		**6%**

700 patients
Mortality: 8,3%
Stroke: 4,3 %
Spinal Cord: 5,1 %

Systematic Review

A systematic review and meta-analysis of hybrid aortic arch replacement



Ann Cardiothorac Surg 2013;2(3):247-260

Konstantinos G. Moulakakis[1,2], Spyridon N. Mylonas[3], Fotis Markatis[1], Thomas Kotsis[3], John Kakisis[1], Christos D. Liapis[1]

Background: Evolution in the endovascular era has influenced the management of aortic arch pathologies. Several studies have described the use of a combined endovascular and open surgical approach to the treatment of arch diseases. Hybrid repair of arch pathologies has been considered as a less invasive method, and is therefore an appealing option for high-risk patients who are unsuitable for open repairs. The aim of the present meta-analysis was to assess the efficacy of hybrid techniques in patients with aortic arch pathologies.

Methods: Extensive electronic literature search was undertaken to identify all articles published up to December 2012 that described hybrid aortic arch repair with intrathoracic supra-aortic branch revascularisation and subsequent stent graft deployment. Eligible studies were divided into two groups: group I included studies on the aortic arch debranching procedure and group II included studies that reported an elephant trunk technique (either "frozen" or stented). Separate meta-analyses were conducted in order to assess technical success, stroke, spinal cord ischemia (SCI), renal failure requiring dialysis, and cardiac and pulmonary complications rate, as well as 30-day/in-hospital mortality.

Results: Forty-six studies were eligible for the present meta-analysis: 26 studies with a total of 956 patients reported aortic arch debranching procedures, and 20 studies with 1,316 patients performed either 'frozen' or stented elephant trunk technique. The pooled estimate for 30-day/in-hospital mortality was 11.9% for the arch debranching group and 9.5% for the elephant trunk group. Cerebrovascular events of any severity were found to have occurred postoperatively at a pooled rate of 7.6% and 6.2%, while irreversible spinal cord injury symptoms were present in a pooled estimate of 3.6% and 5.0% in the arch debranching and elephant trunk group, respectively. Renal failure requiring dialysis occurred at 5.7% and 3.8% in both groups, while cardiac complications rate was 6.0% in the arch debranching cohort and pulmonary complication was 19.7% in the elephant trunk cohort.

Conclusions: Hybrid arch techniques provide a safe alternative to open repair with acceptable short- and mid-term results. However, stroke and mortality rates remain noteworthy. Future prospective trials that compare open conventional techniques with the hybrid method or the entirely endovascular methods are needed.

Debranching
26 studies: 956 pts
Morality: 11,9%
Stroke 7,6
Spinal Cord: 3,6%
Dialysis: 5,7%

FET
20 studies: 1316 pts
Mortality: 9,5%
Stroke: 6,2
Spinal Cord: 5%
Dialysis: 3,8%

Table 1 Descriptive characteristics of eligible studies in the arch debranching group

Author	Study period	N	Mean age (years)	Male [%]	Dissection [%]	Mode of procedure (one stage/staged)	Proximal landing zone (0/1/2)	FU (months)
Andersen *et al*. 2012 (13)	2005-2012	48	65	26 [54]	18 [38]	39/9	48/0/0	28.4
Antoniou *et al*. 2010 (14)	2003-2009	33	63	26 [79]	4 [12]	30/3	9/24/0	6
Bavaria *et al*. 2010 (15)	2005-2009	23	71	18 [78]	0	23/0	23/0/0	20.5
Bergeron *et al*. 2006 (16)	1999-2004	25	72	23 [92]	11 [44]	0/25	15/10/0	15
Canaud *et al*. 2010 (17)	1998-2008	34	ND	ND	ND	24/10	6/4/24	29.9
Chan *et al*. 2008 (18)	2005-2007	16	65	13 [81]	6 [38]	16/0	5/8/3	14
Chiesa *et al*. 2010 (19)	1999-2009	116	70	97 [84]	21 [18]	ND	24/27/65	29
Czerny *et al*. 2012 (4)	2003-2011	66	70	45 [68]	11 [17]	38/28	66/0/0	25
Donas *et al*. 2010 (20)	2005-2008	20	70	15 [75]	1 [5]	20/0	14/2/4	14
Deriu *et al*. 2012 (21)	2004-2010	48	ND	ND	ND	48/0	12/9/27	ND
Ferrero *et al*. 2012 (22)	ND	27	ND	ND	4 [15]	27/0	ND	16.7
Geisbüsch *et al*. 2011 (23)	1997-2009	47	64	33 [70]	15 [32]	24/23	10/25/12	21.4
Gelpi *et al*. 2010 (24)	2004-2009	15	70	12 [80]	2 [13]	3/12	3/7/5	31.4
Gottardi *et al*. 2008 (25)	1996-2007	73	71	ND	9 [12]	0/73	ND	37
Holt *et al*. 2010 (5)	2001-2009	78	67	52 [67]	40 [51]	28/50	9/17/52	12
Hughes *et al*. 2009 (26)	2005-2008	28	64	15 [54]	10 [36]	21/7	13/8/7	14
Ingrund *et al*. 2010 (27)	2007-2009	12	56	6 [50]	9 [75]	ND	4/8/0	11
Ishibashi *et al*. 2012 (28)	2009-2011	12	73	12 [100]	0	0/12	0/12/0	10.2
Lee *et al*. 2011 (29)	2005-2009	37	63	23 [62]	3 [8]	0/37	ND	ND
Lotfi *et al*. 2012 (30)	1997-2011	51	71	34 [67]	11 [22]	10/41	4/31/16	15
Lu *et al*. 2011 (31)	2001-2009	17	49	19 [112]	12 [71]	4/13	1/5/11	27.1
Ma *et al*. 2011 (32)	2005-2010	24	42	16 [67]	24 [100]	ND	3/10/11	33.3
Murashita *et al*. 2012 (33)	2007-2010	27	77	22 [81]	ND	27/0	4/19/4	7
Saleh *et al*. 2006 (34)	2002-2005	15	74	9 [60]	0	0/15	15/0/0	18
Vallejo *et al*. 2012 (35)	2002-2010	38	65	27 [71]	20 [53]	24/14	27/11/0	28.1
Weigang *et al*. 2009 (36)	ND	26	ND	20 [77]	6 [23]	ND	26/0/0	ND

ND, no data; FU, follow-up

Acute type A Dissection

Frozen elephant trunk surgery in acute aortic dissection

Roberto Di Bartolomeo, MD, Antonio Pantaleo, MD, Paolo Berretta, MD, Giacomo Murana, MD, Sebastiano Castrovinci, MD, Mariano Cefarelli, MD, Gianluca Folesani, MD, and Marco Di Eusanio, MD, PhD

(J Thorac Cardiovasc Surg 2014;■:1-5)

Objectives: Acute aortic dissection is a catastrophic condition, for which emergency surgery is the mainstay of therapy. In approximately 70% of patients who survive surgery, a dissected distal aorta remains, posing a risk of late aneurysmal degeneration, rupture, and malperfusion, and secondary extensive interventions are often required.

Methods: In order to improve the long-term prognosis, a more extensive intervention, the frozen elephant trunk (FET) procedure, has been introduced. This involves the simultaneous replacement of the aortic arch and antegrade stenting of the descending thoracic aorta (DTA). Although FET is assumed to produce total thoracic aortic remodeling by inducing both coverage of secondary entry tears located in the proximal DTA and obliteration of the false lumen at the proximal DTA, its role in patients with acute dissection remains controversial mostly because of its technical complexity and increased risk of paraplegia.

Results: Data available in literature show that, after FET interventions, hospital death, stroke, and spinal cord injury occur in 10.0%, 4.8%, and 4.3% of patients with acute dissection, respectively. Available long-term data are sparse but suggest that aortic remodeling with partial or complete thrombosis of the persistent false lumen can be expected in approximately 90% of cases.

Conclusions: The FET technique is a promising approach in patients with acute dissection. Solid long-term data are warranted to validate the assumed short- and long-term benefits, but we believe that thoughtful patient selection criteria remain crucial. (J Thorac Cardiovasc Surg 2014;■:1-5)

TABLE 1. Early and follow-up outcomes after extensive DB1-AAD repair with antegrade stenting of DTA

			30-days or in hospital				Outcomes at follow-up			
Author	Reference	Patients (n)	Death, n (%)	PND, n (%)	SCI, n (%)	Renal failure, n (%)	Mean follow-up (months)	Peri-stent (complete or partial) false lumen thrombosis, n (%)	Distal aortic reoperation, n (%)	Mortality, n (%)
Jakob	ATS 2008;86:95-101	22	2 (9.0)	2 (9.0)	0	12 (54.5)	23	18 (90.0)	2 (10.0)	4 (20.0)
Shimamura	JTCVS 2008;135:1261-9	29	2 (6.8)	(N/A)	4 (13.8)	N/A	60	27 (100)	N/A	N/A
Pochettino	ATS 2009;88:482-9	36	5 (14.0)	1 (3.0)	3 (9.0)	6 (17.0)	16	24 (77.0)	0	0
Chen	ICVTS 2010;11:594-8	27	4 (14.8)	3 (11.1)	0	2 (7.4)	30	23 (100)	1 (4.3)	2 (8.7)
Jakob	JCS 2011;52:717-23	88	16 (18.0)	5 (6.0)	5 (6.0)	32 (36.4)	—	72 (100)	N/A	N/A
Sun	ATS 2011;91:1147-52	148	7 (4.7)	4 (2.7)	3 (2.0)	1 (0.7)	42	133 (94)	1 (0.7)	4 (2.8)
Uchida	EJCTS 2011;40:1066-71	80	4 (5.0)	2 (2.5)	0	3 (3.8)	74.3	76 (100)	6 (7.9)	5 (6.6)
Shi	JTCVS 2011;142:1458-63	46	1 (2.2)	0	0	—	14	45 (100)	0	0
Shen	EJCTS 2012;41:e12-7	22	2 (9.1)	—	1 (4.5)	—	12	20 (100)	0	0
Hoffman	JTCVS 2013;145:964-9	32	1 (3.1)	0	0	0	17	31 (100)	0	1 (3.1)
Xiao	JTCVS 2013;147:639-43	33	6 (18.2)	0	0	1 (3.0)	27	—	N/A	1 (3.7)
Shrestha	EJCTS 2013;43:406-10	18	5 (27.7)	(N/A)	0	—	—	—	2 (15.4)	N/A
Roselli	JTCVS 2013;145:S197-201	17	0	2 (12.0)	0	3 (19)	5	15 (88)	1 (6.0)	0

ATS, Annals of Thoracic Surgery; *JTCVS*, Journal of Thoracic and Cardiovascular Surgery; *ICVTS*, Interactive Cardiovascular and Thoracic Surgery; *JCS*, Journal of Cardiac Surgery; *EJCTS*, European Journal of Cardio-Thoracic Surgery; *PND*, permanent neurologic dysfunction; *SCI*, spinal cord injury; *N/A*, not applicable.

THE FET TECHNIQUE: IS IT JUSTIFIED IN ALL PATIENTS WITH ACUTE DISSECTION?

Since 1996, 140 patients have undergone the FET procedure at our institution to treat patients with extensive diseased of the thoracic aorta, of whom only 10 had a type A acute aortic dissection. We have been cautious in adopting the FET procedure for acute aortic dissection for several reasons. First, not all surgeons are fully involved in our institutional FET program and we strongly discourage surgeons who have less experience with total arch replacement from using a FET. Second, not all patients are good candidates for the FET technique. These extensive operations inevitably increase the patient's surgical trauma as a result of the necessary prolonged periods of extracorporeal circulation, circulatory arrest, myocardial ischemia, and ASCP. For this reason, we use a conservative approach in elderly patients (>75 years) and in those who present with a critical status, as determined by prolonged shock/tamponade, brain injury, or advanced mesenteric ischemia. Younger patients with no severe complication related to acute dissection and those with a complex distal tear or aortic rupture are the best candidates for the FET technique.

CONCLUSIONS

Surgical techniques involving stenting of the descending thoracic aorta during primary surgery for DeBakey type I acute aortic dissections are associated with promising results. When used by experienced surgeons on selected patients, these techniques do not seem to be associated with an increased risk of hospital death or stroke. In contrast, by inducing distal false lumen obliteration and thrombosis, the FET technique is likely to improve long-term survival and reduce the need for secondary or tertiary procedures. Nevertheless, additional studies designed to confirm this hypothesis are warranted. Meanwhile, in the case of acute dissection, experienced operators should perform the FET technique in appropriately selected patients.

Mortality: 10 %
Stroke: 4,8 %
Spinal Cord: 4,3 %
False lumen thrombosis: 90 %

Frozen elephant trunk with total arch replacement for type A aortic dissections: Does acuity affect operative mortality?

Wei-Guo Ma, MD,[a,b,c] Jun Zheng, MD,[a,b] Wei Zhang, MD,[a] Kai Sun, MD, PhD,[b] Bulat A. Ziganshin, MD,[c] Long-Fei Wang, MD,[a] Rui-Dong Qi, MD,[a,b] Yong-Min Liu, MD,[a,b] Jun-Ming Zhu, MD,[a,b] Qian Chang, MD,[b] John A. Elefteriades, MD,[c] and Li-Zhong Sun, MD[a,b]

(J Thorac Cardiovasc Surg 2014;148:963-72)

Conclusions: In this group of patients with type A dissection, acuity was not a risk factor for operative mortality after the Sun procedure. Patients with previous cerebrovascular disease; malperfusion of the brain, kidneys, spinal cord, and/or viscera; concomitant extra-anatomic bypass; and a longer cardiopulmonary bypass time (>180 minutes) were at greater risk of operative mortality. (J Thorac Cardiovasc Surg 2014;148:963-72)

Influence of operative strategy for the aortic arch in DeBakey type I aortic dissection: Analysis of the German Registry for Acute Aortic Dissection Type A

Jerry Easo, MD,[a] Ernst Weigang, MD, PhD,[b] Philipp P. F. Hölzl, MD,[a] Michael Horst, MD,[a] Isabell Hoffmann, MS,[c] Maria Blettner, MS, PhD,[c] and Otto E. Dapunt, MD, PhD,[a] for the GERAADA study group

(J Thorac Cardiovasc Surg 2012;144:617-23)

Conclusions: On analysis of the GERAADA data, it seems that a more aggressive approach of aortic arch treatment can be applied without higher perioperative risk even in the onset of acute aortic dissection type A. Long-term follow-up data analysis will be necessary to offer the optimal surgical strategy for different patient groups. (J Thorac Cardiovasc Surg 2012;144:617-23)

Art of Operative Techniques

Sun's procedure for complex aortic arch repair: total arch replacement using a tetrafurcate graft with stented elephant trunk implantation

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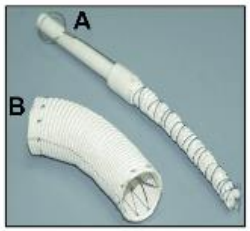
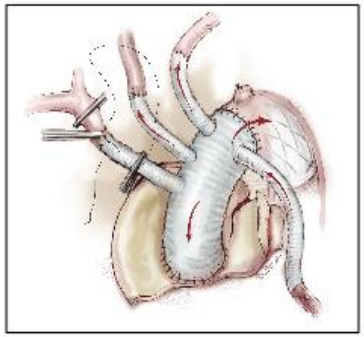
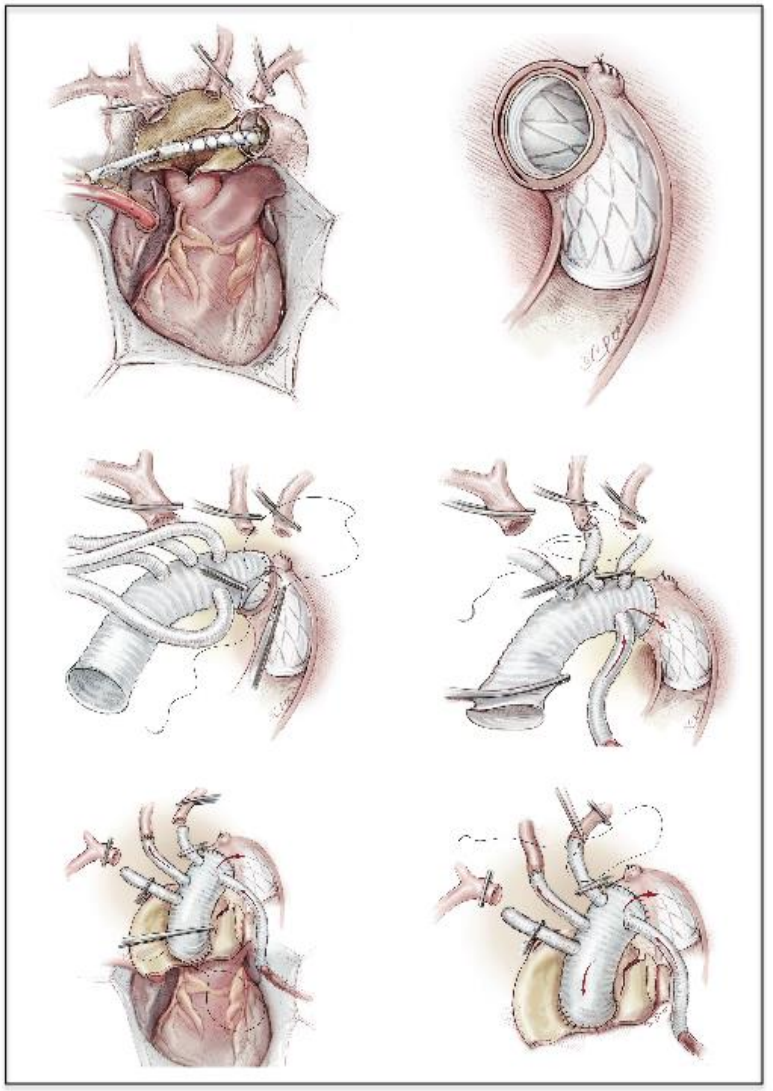
Ann Cardiothorac Surg 2013;2(5):642-648

35 patients
Mortality: 8,5 %
Stroke: 2,4%
Spinal Cord Injury: 0,3%







Acute type B Dissection Involving Aortic Arch

The frozen elephant trunk technique for the treatment of complicated type B aortic dissection with involvement of the aortic arch: multicentre early experience†

European Journal of Cardio-Thoracic Surgery (2014) 1–9

Gabriel Weiss[a,*], Konstantinos Tsagakis[b], Heinz Jakob[b], Roberto Di Bartolomeo[c], Davide Pacini[c], Giuseppe Barbero[d], Jorge Mascaro[e], Carlos-A. Mestres[e], Thanos Sioris[f] and Martin Grabenwoger[a]

OBJECTIVES: Treatment of complicated type B aortic dissection (TBAD) with involvement of the proximal descending or ascending aorta is challenging, especially if the aortic anatomy is contraindicated for thoracic endovascular aortic repair (TEVAR). We present the early results of a multicentre study using the frozen elephant trunk (FET) technique for type B AD.

METHODS: From January 2005 to March 2013, data from 465 patients who had undergone treatment with the FET technique were collected in the database of the International E-vita Open Registry. From this cohort, 57 patients who had a primary indication for surgery for type B AD were included in the present study. Their mean age was 58 ± 12 years, and 72% had a chronic dissection. All operations were performed in circulatory arrest and bilateral antegrade cerebral perfusion. Computed aortic imaging was performed for false lumen (FL) evaluation during the follow-up.

RESULTS: The in-hospital mortality rate was 14% (8/57). Stroke and spinal cord injury occurred in 6 (10%) and 2 patients (4%), respectively. The rate of immediate FL thrombosis at the level of the stent graft was 75% (40/53) and increased to 97% (41/42) during the follow-up period (23 ± 19 months). Distally, at the level of the abdominal aorta, the FL remained patent in 50% (21/42) of patients. The 1- and 3-year survival was 81 and 75%, respectively.

CONCLUSION: The FET technique is a feasible therapeutic option for complicated type B AD with involvement of the aortic arch if TEVAR is contraindicated. In contrast to conventional aortic surgery via a lateral thoracotomy, the FET procedure can provide simultaneous treatment of the ascending aorta and aortic arch.

Mortality : 14 %
Stroke : 10 %
Spinal Cord: 4 %

Table 3: Univariate analysis of in-hospital mortality

Variables	Number of patients (%)	Number of deaths (%)	*P*-value
Dissection			0.6
Acute	16 (28)	2 (13)	
Chronic	41 (72)	6 (15)	
Renal insufficiency			0.055
Creatinine >2 mg/dl			
No	50 (88)	5 (10)	
Yes	5 (9)	2 (40)	
N/A	2 (3)	1 (50)	
Neurological deficit			0.05
No	50 (88)	5 (10)	
Yes	7 (12)	3 (43)	
Ejection fraction			0.002
<40	2 (3)	2 (100)	
40–60	25 (53)	3 (12)	
>60	30 (44)	3 (10)	
Peripheral vascular disease			0.017
No	52 (91)	5 (10)	
Yes	5 (9)	3 (60)	
Use of guide wire			0.016
No	9 (16)	4 (44)	
Yes	48 (84)	4 (8)	
Low output syndrome			0.001
No	49 (86)	3 (6)	
Yes	8 (14)	5 (63)	
Postoperative dialysis			0.005
No	46 (81)	3 (7)	
Yes	11 (19)	5 (46)	
Postoperative bowel ischaemia			0.002
No	54 (95)	5 (9)	
Yes	3 (5)	3 (100)	
Stroke			0.84
No	51 (89)	7 (14)	
Yes	6 (11)	1 (17)	
Diabetes			0.09
No	50 (88)	6 (12)	
Yes	5 (9)	2 (40)	
N/A	2 (3)		
Gender			0.44
Female	15 (26)	3 (20)	
Male	42 (74)	5 (12)	
Intubation time			0.022
<24 h	31 (54)	1 (3)	
>24 h	24 (42)	6 (25)	
N/A	2		
Malperfusion			0.11
Yes	10 (18)	3 (30)	
No	47 (82)	5 (11)	
COPD			0.1
No	47 (82)	5 (11)	
Yes	10 (18)	3 (30)	
Previous cardiovascular surgery			0.4
No	36 (63)	4 (11)	
Yes	21 (37)	4 (19)	
Previous descending stenting			0.23
No	50 (88)	6 (12)	
Yes	7 (13)	2 (29)	

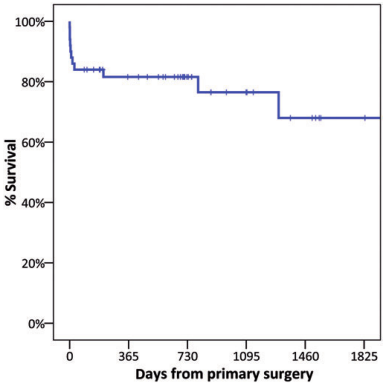


Figure 1: Actuarial survival rate after frozen elephant trunk repair in type B aortic dissection. Kaplan–Meier in overall dissection during the follow-up.

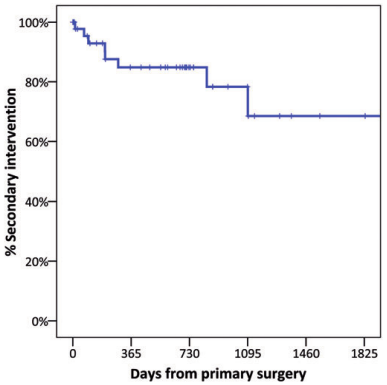


Figure 2: Freedom from reintervention after frozen elephant trunk repair in type B aortic dissection. Kaplan–Meier in overall dissection during the follow-up.

Chronic Aortic Dissection

The Frozen Elephant Trunk for the Treatment of Chronic Dissection of the Thoracic Aorta: A Multicenter Experience

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Carlos-A. Mestres, MD, Alessandro Armaro, MD, Gabriel Weiss, MD,
Martin Grabenwoger, MD, Michael A. Borger, MD, Friedrich W. Mohr, MD,
Robert Stuart Bonser, MD, and Roberto Di Bartolomeo, MD

(Ann Thorac Surg 2011;92:1663–70)

Background. Because of the extensive involvement of the aorta, surgical treatment of its chronic dissection continues to represent a surgical challenge. We conducted a study of a multicenter experience to describe a multicenter experience in the treatment of this complex pathology, using the frozen elephant trunk (FET) technique.

Methods. Between January 2005 and May 2010, 240 patients underwent treatment with the FET technique and had their clinical data collected in the International E-vita Open Registry. Ninety of the patients, who were the population in the present study, underwent operations for chronic dissection of the aorta (type A, 77%). The mean age of these 90 patients was 57 ± 12 years, and 72 (80%) of the patients were male. Sixty-two patients (69%) had undergone a previous aortic operation. All of the procedures in the study were performed with the aid of antegrade selective cerebral perfusion.

Results. Total replacement of the aortic arch was done in 84 patients (93%). Cardiopulmonary bypass, myocardial ischemia, cerebral perfusion, and visceral ischemia times were 243 ± 65, 145 ± 48, 86 ± 24, and 75 ± 22 minutes, respectively. In-hospital mortality was 12% (11 patients). One patient died from a stroke and 8 patients (9%) died from ischemic spinal cord injury. The false lumen (FL) in the patients' aortae was evaluated with computed tomography after operation and during follow up. The rates of complete thrombosis of the FL around the elephant trunk were 69% and 79% at the first and last postoperative examinations, respectively. The rates of 4-year survival and freedom from aortic reoperation were 78% ± 5% and 96% ± 3%, respectively.

Conclusions. The treatment of chronic aortic dissection (AD) with the FET technique is feasible, with respectable results. The rate of aortic reoperation with the use of this technique appears to be lower than that with a conventional approach to the repair of chronic AD. Ischemic spinal cord injury represents a concerning complication of the FET technique but seems to be unrelated to thrombosis of the FL.

(Ann Thorac Surg 2011;92:1663–70)

Table 3. Postoperative Data

Variable	No. (%)
In-hospital mortality	11 (12)
Low-output syndrome	7 (8)
Intubation >72 hours	28 (31)
Rethoracotomy for bleeding	12 (13)
Dialysis	
Permanent	4 (4)
Temporary	14 (16)
Gastrointestinal complications	4 (4)
Stroke	1 (1)
TND	6 (7)
Spinal cord injury	
Paraplegia	4 (4)
Paraparesis	4 (4)

TND = transient neurologic dysfunction.

Table 4. Univariate Analysis of In-Hospital Mortality

Variable	No. of Patients (%)	No. of Deaths (%)	*p* Value
Creatinine >2 mg/dL			
No	82 (91)	8 (10)	0.055
Yes	8 (9)	3 (38)	
Oversizing >10%			
No	75 (83)	7 (9)	0.082
Yes	15 (17)	4 (27)	
Stent graft placement without guide wire			
No	77 (86)	4 (5)	<0.001
Yes	13 (14)	7 (54)	
Sacrifice of LSA			
No	81 (90)	8 (10)	0.077
Yes	9 (10)	3 (33)	
Intubation >72 hours			
No	62 (69)	4 (7)	0.030
Yes	28 (31)	7 (25)	
Postoperative dialysis			
No	72 (80)	6 (8)	0.039
Yes	18 (20)	5 (28)	
Permanent postoperative dialysis			
No	86 (96)	8 (9)	0.005
Yes	4 (4)	3 (75)	
Gastrointestinal complication			
No	86 (96)	8 (9)	0.005
Yes	4 (4)	3 (75)	

LSA = left subclavian artery.

Table 6. Behavior of Aortic False Lumen as Assessed With Computed Tomography

	PreDischarge No. (%)	Follow-Up No. (%)
Stent graft level		
Complete thrombosis	58/83 (70)	60/65 (92)
Partial thrombosis	16/83 (19)	4/65 (6)
Patent	9/83 (11)	1/65 (2)
Distal descending thoracic aorta		
Complete thrombosis	23/83 (28)	31/65 (48)
Partial thrombosis	26/83 (31)	21/65 (32)
Patent	34/83 (41)	13/65 (20)
Abdominal aorta		
Complete thrombosis	10/79 (13)	4/62 (6)
Partial thrombosis	3/79 (4)	8/62 (13)
Patent	66/79 (83)	50/62 (81)

Extended Aortic Repair Using Frozen Elephant Trunk Technique for Marfan Syndrome with Acute Aortic Dissection

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Ann Thorac Cardiovasc Surg 2013; 19: 279–282

Purpose: The aim of this study was to analyze midterm results of frozen elephant trunk technique for Marfan syndrome with acute aortic dissection.

Methods: Between February 1999 and August 2011 we performed arch replacement uisng frozen elephant trunk technique for acute aortic dissection in 8 patients with Marfan syndrome containing two complicated type B dissections and six type A dissections. Five patients compromised annulo-aortic ectasia who performed Bentall operation.

Results: No patients died in the initial operation. Fate of false lumen on the stent graft border was expressed by CT scan follow-up that were patent in 0, thrombosis in 5 and absorption in 3 patients. One patient who had new aortic dissection 8 years after initial surgery required the Crawford V operation. Ten-years-survival rate was 100% and ten years-event free rate was 67%.

Conclusions: Frozen elephant trunk technique was feasible for Marfan syndrome with acute aortic dissection and might become alternative prophylactic treatment to the downstream aorta for acute aortic dissection.

Marfan...

... TAA

Thoracoabdominal aortic aneurysm repair after frozen elephant trunk procedure†

Sandra Folkmann[a,*], Gabriel Weiss[a], Harald Pisarik[a], Martin Czerny[b] and Martin Grabenwoger[a]

European Journal of Cardio-Thoracic Surgery (2014) 1–5

OBJECTIVES: To evaluate the feasibility and the outcomes of second-stage thoracoabdominal (TA) repair after previous frozen elephant trunk (FET) implantation.

METHODS: Between 2005 and 2013, 41 patients underwent open TA aortic repair in our institution. Of these, 9 patients (78% male) underwent second-stage TA repair after previous FET implantation. Feasibility and outcomes were evaluated.

RESULTS: The mean interval between FET implantation and second-stage TA repair was 423 days (19–1979 days). Indications for second-stage TA repair were progression in aortic diameter of atherosclerotic aneurysms in the downstream segments in 6 patients, diameter progression in post-dissection aneurysms in 2 patients and giant cell aortitis with aneurysm formation in another patient. There were no in-hospital deaths. The median intensive care unit stay was 3.5 days (range: 1–12 days) and median hospital stay was 22 days (range: 14–132 days). We did not observe symptomatic spinal cord ischaemia or stroke. One patient (11%) developed acute renal failure requiring haemodialysis.

CONCLUSION: Second-stage TA aortic repair after previous frozen elephant implantation is a feasible and effective treatment modality for patients with various pathologies of downstream aortic segments. This approach adds additional value to the conventional elephant trunk technique by providing an excellent landing zone not only for additional stent graft procedures but also for subsequent open TA repair.

FET Device

- *Ease of deployment , without increasing technical complexity and prolonging ischemic and perfusion durations*
- *Avoidance of fluoroscopy and guide wires*
- *Firm fixation to the aortic wall*
- *conformation to the curvature of the aorta*
- *Tapered distal end to fit well within the descending aorta*

CONCLUSIONS

- **FET procedure is easier than the ET procedure**
- **Use the Short Distal StentGraft is safer (Keep in mind two stages procedures)**
- ***Ease of anastomosis in secondary distal interventions, exspecialy for* secondary endovascular procedure**
- **Alternative treatment to endovascular failure**