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Is Hybrid Surgical Approach the Best Choice for Aortic Arch Aneurysms?

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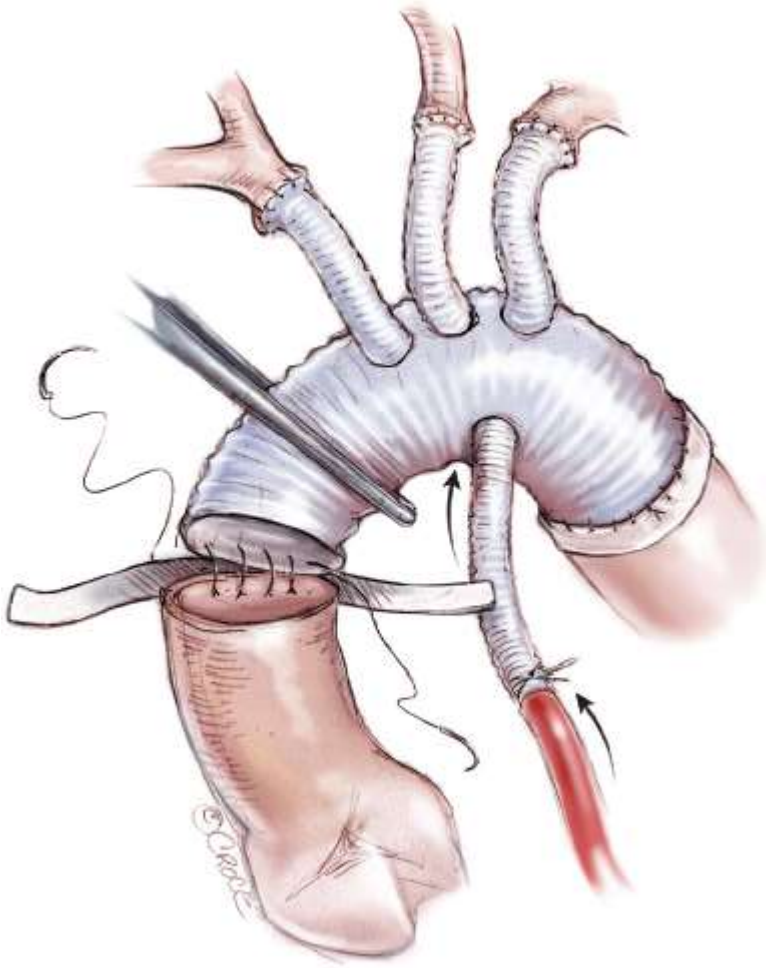
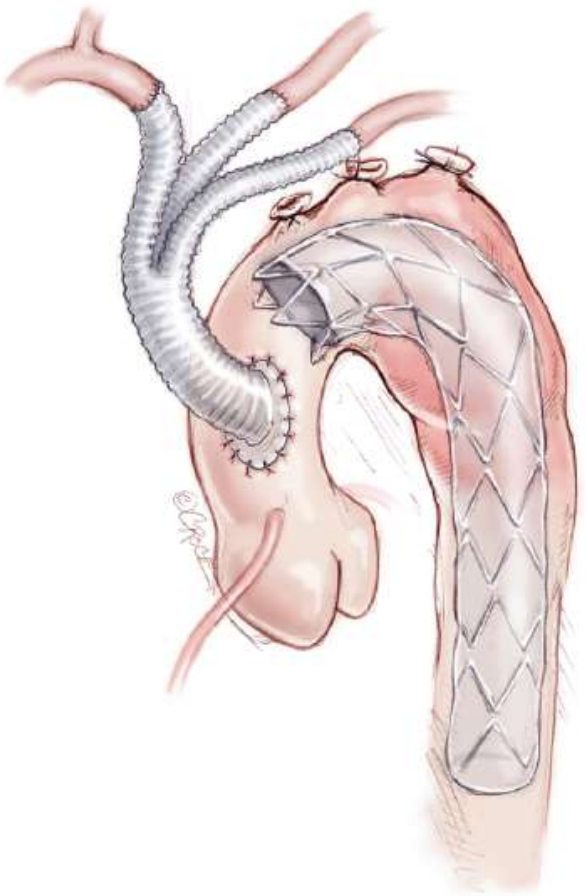
Ishimaru Classification of Proximal Landing Zones

Chiesa R et al. J Vasc Bras. 2008;7(2):90-98



Open repair has shown both early survival benefit and long term durable outcomes



There is a general assumption that endovascular hybrid arch procedures are less invasive and therefore more likely to result in superior survival benefit to open repair

Moulakakis KG, et al. A systematic review and meta-analysis of hybrid aortic arch replacement. Ann Cardiothorac Surg 2013;2(3):247-260

Although hybrid arch procedures have shown comparable early outcomes to open procedures, long term durability remains uncertain

Systematic Review

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

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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 revascularization 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 936 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 9.1% 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 3.0% in the arch debranching and elephant trunk group, respectively. Renal failure requiring dialysis occurred at 3.7% 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.

Keywords: Aortic arch, hybrid; debranching; frozen elephant trunk; stented elephant trunk

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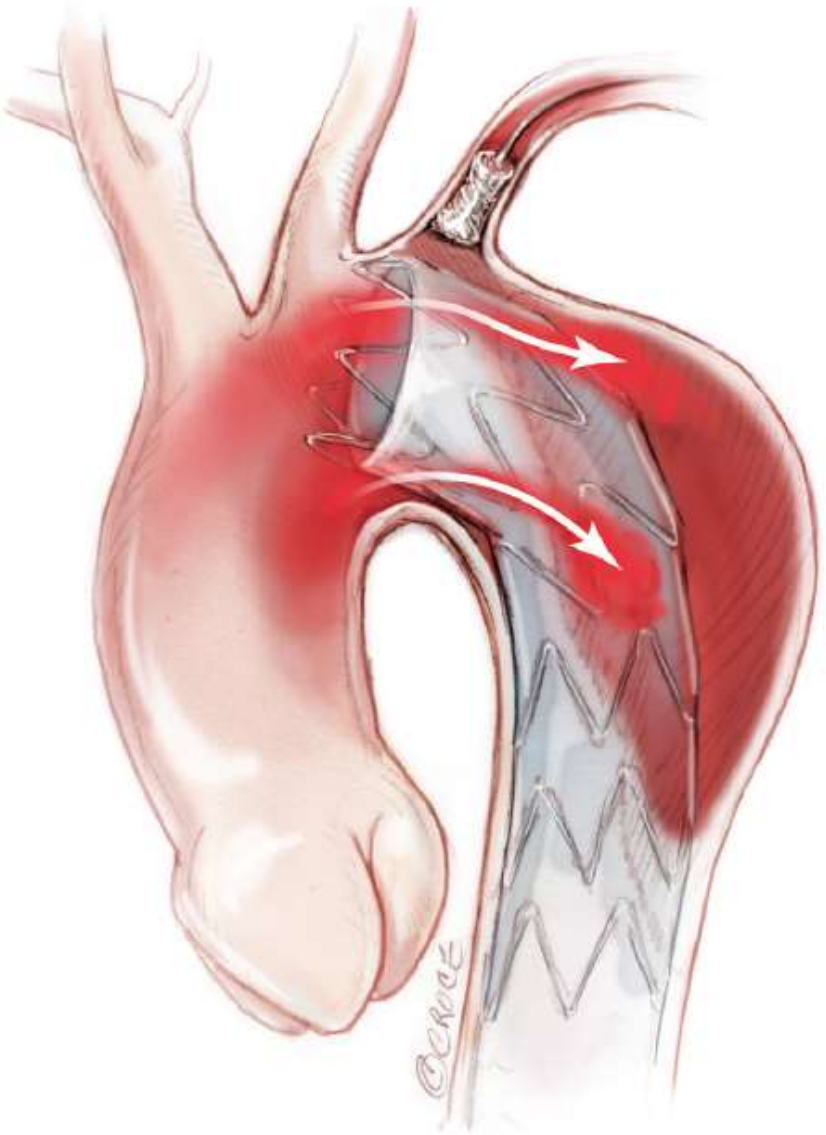

Endoleaks are uniquely associated with endovascular procedures, and this is a major drawback which must be taken into consideration when choosing the treatment modality

Trimarchi S, et al. Emergent treatment of aortic rupture in acute type B dissection. Ann Cardiothorac Surg 2014;3(3):319-324

Issues at Large

- Is Hybrid endovascular procedure really less invasive?
- Short and long term outcomes?
- Aortic arch aneurysms that may benefit from hybrid procedures?
- Can hybrid endovascular arch procedures actually be detrimental?
- When should we turn to hybrid procedure?

Analysis of Ascending and Transverse Aortic Arch Repair in Octogenarians

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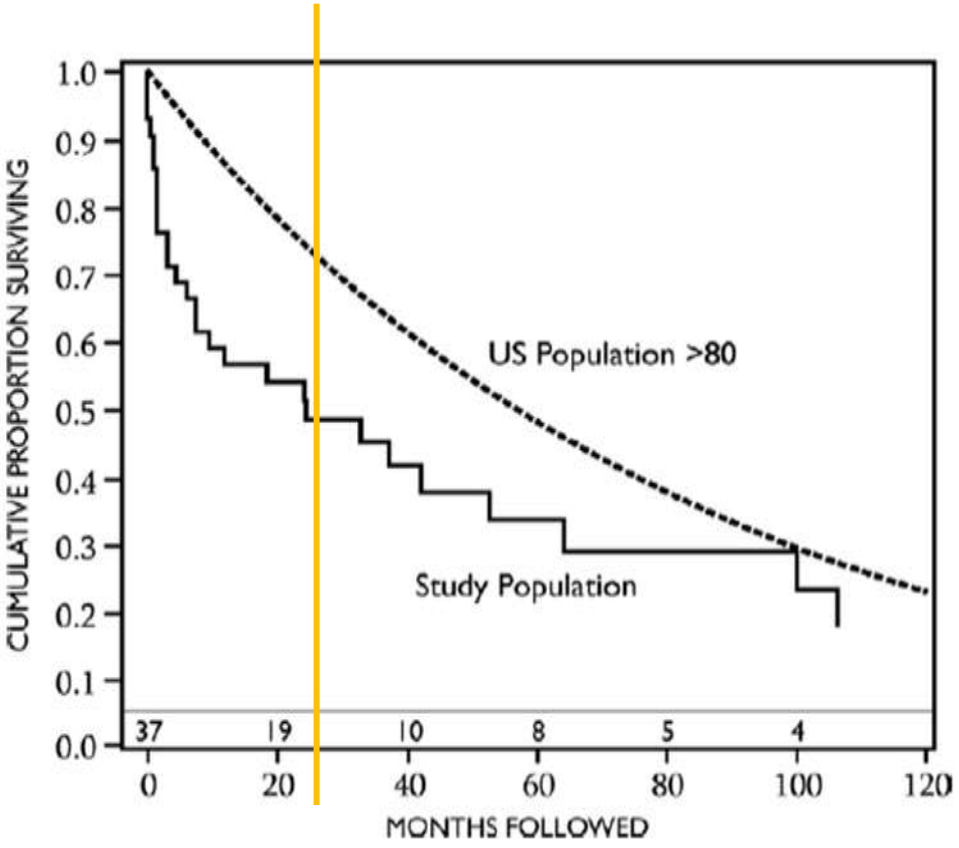
Background. Increasing numbers of older patients are requiring complex thoracic aortic surgery. This retrospective study analyzed early and late outcomes after ascending and transverse arch surgery using hypothermic circulatory arrest (HCA).

Methods. Between January 1991 and December 2006, 779 patients requiring HCA were treated. Outcomes are reported by age group: group 1, 80 years or more (37, 4.8%); and group 2, less than 80 years (742, 95.2%). Univariate and multivariate analyses were used to identify risk factors for morbidity and mortality.

Results. Early mortality and stroke did not differ between groups. Thirty-day mortality was13.5% (5 of 37) in group 1 and 10% (78 of 742) in group 2 ($p = 0.57$). Stroke occurred in 8% (3 of 37) of group 1 patients and 2.7% (20 of 742) of group 2 patients ($p = 0.09$). Predictors of stroke were prior stroke ($p = 0.003$) and pump time ($p = 0.02$). Predictors of early mortality were low glomerular filtration rate ($p = 0.0001$), long cardiopulmonary bypass time ($p = 0.0001$), and emergent repair ($p = 0.0009$). Retrograde cerebral perfusion was protective against stroke ($p = 0.0001$) and reduced early mortality ($p = 0.02$). Age was not a predictor of stroke ($p = 0.12$) or early mortality ($p = 0.39$). Survival in group 1 compared with the age-matched US population at 1 year was 56% versus 86% ($p = 0.02$); at 2 years, 48% versus 76% ($p = 0.03$); at 5 years, 36% versus 48% (not significant); and at 10 years, 20% versus 20%.

Conclusions. Ascending and aortic arch surgery in octogenarians involving profound HCA resulted in reasonable morbidity and short- and long-term mortality rates. The use of profound HCA for aortic surgery remains warranted in octogenarians.

(Ann Thorac Surg 2008;86:774–9)



Comparison of long-term survival between octogenarians and the normal United States octogenarian population.

Survival

Survival in group 1 compared with the age-matched United States population postoperatively was 56% versus 86% ($p = 0.02$) at year 1, 48% versus 76% ($p = 0.03$) at year 2, 36% versus 48% at year 5, and 20% versus 20% at year 10 ($p > 0.10$). Thus, survival differences, when compared with the age-matched US population, were present as long as 2 years postoperatively, but disappeared after 2 years ($p = 0.10$; Fig 1). The only multivariate predictor of improved long-term survival was use of retrograde cerebral perfusion ($p = 0.03$).

Open arch reconstruction in the endovascular era: Analysis of 721 patients over 17 years

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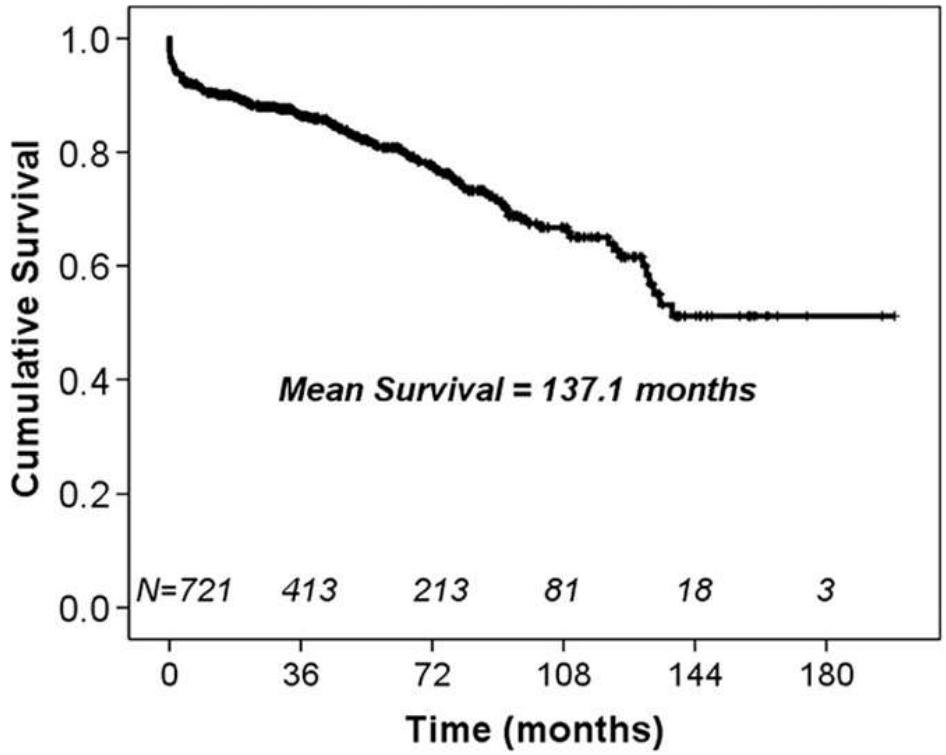
Objective: Recent advancements in thoracic endovascular aortic repair, such as branched endografts or hybrid debranching/thoracic endovascular aortic repair, have extended the option of endoluminal therapy into the realm of the aortic arch. A contemporary assessment of open arch repair to provide long-term data for comparative analysis for these newer therapies is timely, warranted, and presented in this article.

Methods: Since the inception of our thoracic endovascular aortic repair program in 1993, 721 patients (mean age of 59.3 years, 68.9% were male) have undergone median sternotomy and open arch reconstruction with hypothermic circulatory arrest. Extended arch repair was performed in 42.7% with construction of bypasses to the innominate (296 patients), left carotid (216 patients), and subclavian (75 patients) arteries or elephant trunk procedures (42 patients). Concomitant aortic valve or aortic root replacement was required in 403 patients, and root reconstruction was required in 222 patients. Retrograde (641 patients) or antegrade (400 patients) cerebral perfusion was used for neuroprotection during hypothermic circulatory arrest. The operative procedure was urgent or emergency in 316 patients (43.8%) and included repair of type A dissection in 284 patients (39.3%). A total of 111 patients (15.4%) had undergone prior cardiac surgery. Primary outcomes in this study were early and late mortality. Follow-up was 100% complete (mean, 52.6 months).

Results: Thirty-day morbidity included death (36 patients [5%]), stroke (34 patients [4.7%]), and permanent dialysis (14 patients [1.9%]). Independent predictors of early mortality included advancing age, prolonged bypass times, and impaired ejection fraction (all $P < .05$). Actuarial survival at 10 years was 65%. Independent predictors of late mortality included advancing age, prolonged lower body circulatory arrest times, and increasing creatinine (all $P < .05$). By Kaplan–Meier analysis, 10-year survival was significantly reduced after operative procedures for type A dissection (non–type A 69.1% vs type A 58%, $P = .003$). Freedom from aortic reoperation (any segment) was 72.6% at 10 years.

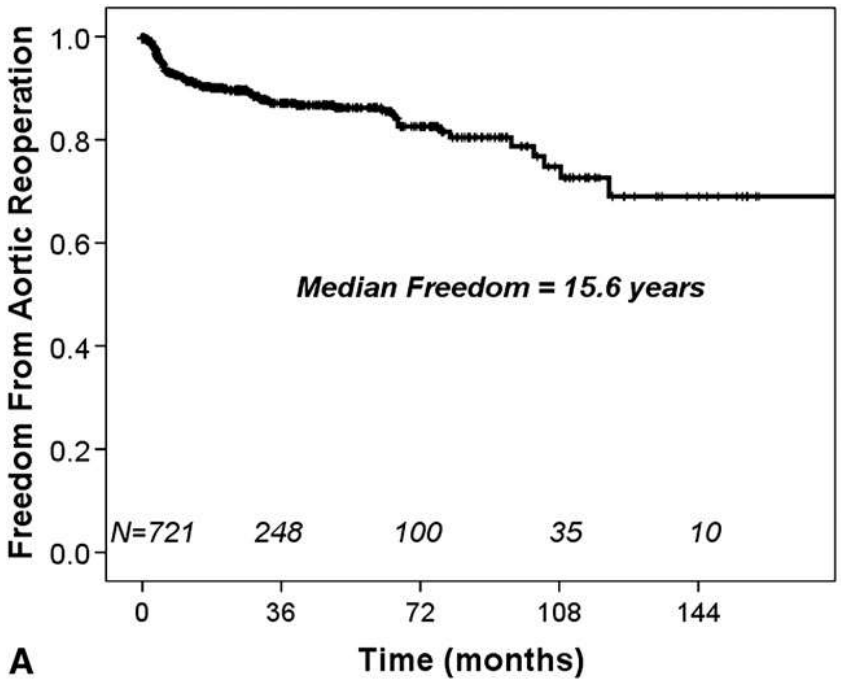
Conclusions: Open aortic arch repair can be accomplished with excellent early and late results. These outcomes provide objective data for comparison and suggest that newer endovascular therapies should be evaluated first in high-risk groups, such as those with advanced age or impaired renal function before broader application in all patients. (J Thorac Cardiovasc Surg 2011;141:1417-23)

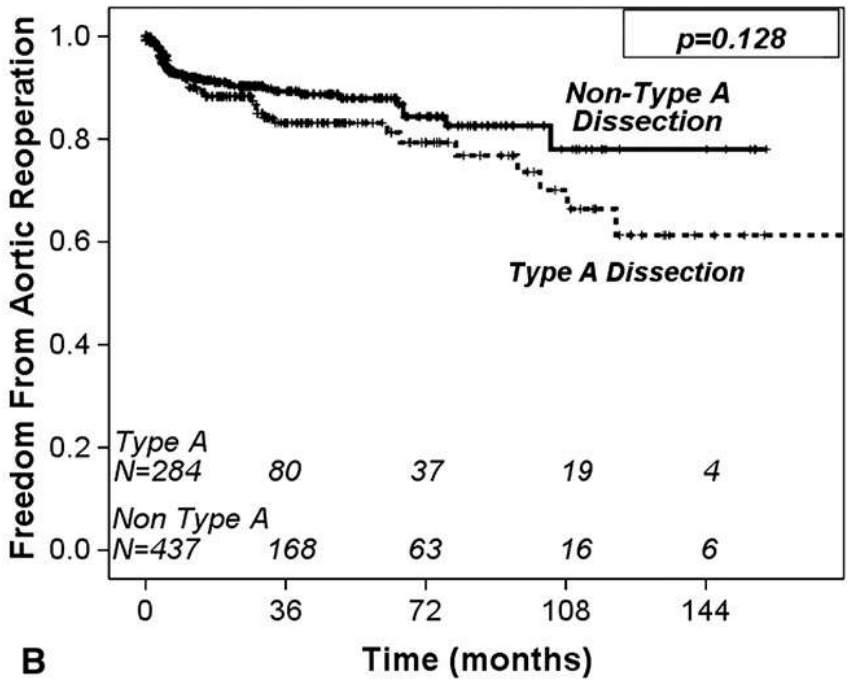
Long Term Survival Outcomes



Kaplan–Meier survival analysis for the entire cohort. The 12-year survival for the entire cohort is 51.2% ± 0.5%.

Late Aortic Events





A, Kaplan–Meier analysis of late aortic events. Freedom from late aortic reoperation at any segment was 72.6% ± 0.4% at 10 years. Although risk for late reoperation was not significantly different between type A and non–type A pathologic groups (B, log rank P = .128), examination of the data suggests that the curves separated early and that more robust patient numbers with longer follow-up may demonstrate a difference.

Is Conventional Open Repair Still a Good Option for Aortic Arch Aneurysm in Patients of Advanced Age?

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Background. Although thoracic endovascular aortic repair has advantages in elderly patients, it is not always applicable, and some elderly patients require open surgical repair.

Methods. Between 2008 and 2014, 157 patients (11 men) older then 75 years (mean age, 79.3 ± 3.3 years) underwent conventional total arch replacement, of which 39 were emergency operations. Coexisting diseases included remote stroke in 54 patients, coronary artery disease in 64, chronic obstructive pulmonary disease in 25, and chronic kidney disease in 112. Concomitant procedures were performed in 46 patients.

Results. Mean follow-up time was 2.9 ± 1.8 years. Mean cardiopulmonary bypass time was 251.1 ± 68.4 minutes. Mean lowest nasopharyngeal temperature was 23.2° ± 3.4°C. The hospital mortality rate was 7.6% (12 of 157) overall, 5.1% in elective cases, and 15.4% in emergency cases. Postoperative complications included permanent neurologic dysfunction in 5.7% of patients and prolonged ventilation time exceeding 72 hours in 13.4%. No spinal cord complications occurred. The 1-year and 5-year survival rates were 88.2% and 69.2% in all cases and 91.3% and 77.0% in elective cases, respectively. Univariate analysis demonstrated that risk factors for hospital death in elective cases were chronic kidney disease (odds ratio, 4.00; $p = 0.028$) and ventilation time exceeding 72 hours (odds ratio, 13.3; $p = 0.001$).

Conclusions. Even in patients older than 75 years, recent surgical results of conventional open arch repair were acceptable, especially in elective cases. Thus, conventional open surgical aortic arch replacement remains a good option, especially in patients with preserved renal function.

(Ann Thorac Surg 2016;101:80–6)

Elective vs Emergency

Outcomes	Overall (N = 157) % (No.)	Elective (n = 118) % (No.)	Emergency (n = 39) % (No.)	*p* Value
Hospital mortality	7.6 (12)	5.1 (6)	15.4 (6)	0.036
Major adverse events				
Neurologic				
PND	5.7 (9)	2.5 (3)	15.4 (6)	0.003
TND	8.9 (14)	7.6 (9)	12.8 (5)	0.325
Paraplegia	0	0	0	
AMI	1.3 (2)	1.7 (2)	0	
AKI requiring dialysis	3.8 (6)	2.5 (3)	7.8 (3)	0.147
Mediastinitis	1.3 (2)	1.7 (2)	0	
Respiratory				
Ventilation >24 h	35.0 (55)	25.4 (30)	64.1 (25)	0.001
Ventilation >72 h	13.4 (21)	7.6 (9)	30.8 (12)	0.001
Tracheotomy	5.7 (9)	3.4 (4)	12.8 (5)	0.029
Pneumonia	3.2 (5)	2.5 (3)	5.1 (2)	0.429

AKI = acute kidney injury; AMI = acute myocardial infarction; PND = permanent neurologic dysfunction; TND = transient neurologic dysfunction.

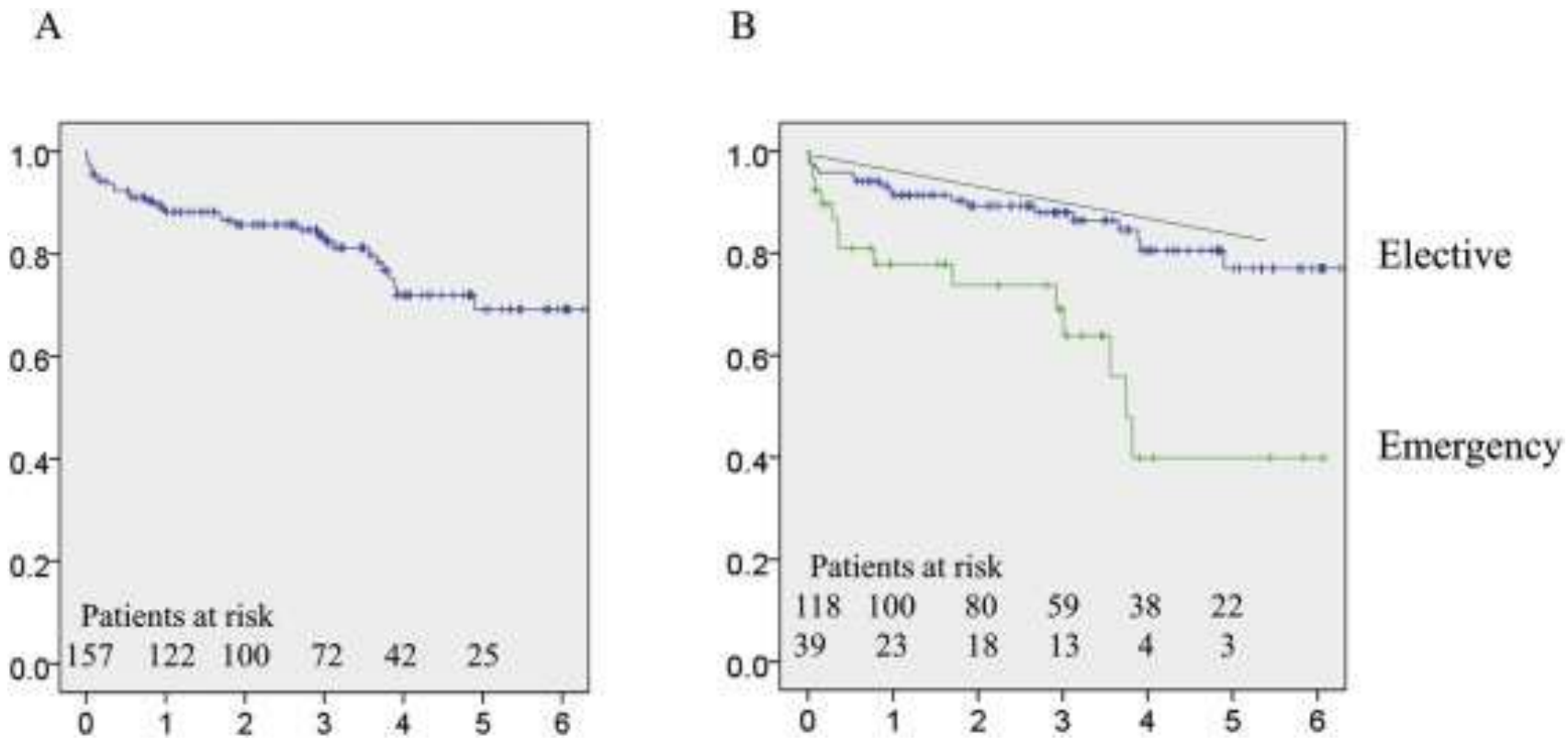
The frequency of permanent neurologic dysfunction and prolonged ventilation time was significantly higher in emergency than in elective cases (p = 0.003 and p = 0.001, respectively).

Elective outcomes; >80 vs 75-79

Outcomes	All Elective (n = 118) % (No.)	>80 Years (n = 41) % (No.)	75–79 Years (n = 77) % (No.)	*p* Value
Hospital mortality	5.1 (6)	7.3 (3)	3.9 (3)	0.425
Major adverse events				
Neurologic				
PND	2.5 (3)	4.9 (2)	1.3 (1)	0.331
TND	7.6 (9)	7.3 (3)	7.8 (6)	0.927
Paraplegia	0	0	0	
AMI	1.7 (2)	2.4 (1)	1.3 (1)	0.651
AKI required dialysis	2.5 (3)	7.3 (3)	0	0.083
Mediastinitis	1.7 (2)	4.9 (2)	0	0.160
Respiratory				
Ventilation >24 h	25.4 (30)	24.4 (10)	26.0 (20)	0.937
Ventilation >72 h	7.6 (9)	9.8 (4)	6.5 (5)	0.492
Tracheotomy	3.4 (4)	7.3 (3)	1.3 (1)	0.170
Pneumonia	2.5 (3)	2.4 (1)	2.6 (2)	0.959

AMI = acute myocardial infarction; AKI = acute kidney injury; PND = permanent neurologic dysfunction; TND = transient neurologic dysfunction.

The differences in major adverse events between the two groups were not significant.



(A) The postoperative survival curve in all patients. (B) The postoperative survival curve in elective (blue line) patients, shows the rates of 91.3% at 1 year and 77.0% at 5 years, and in emergency (green line) patients, shows the rates of 77.8% at 1 year and 69.1% at 3 years. The dotted line represents the survival curve of 75-year-olds in the normal Japanese population.

Endovascular Aortic Arch Repair: Hopes and Certainties

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KEYWORDS
Aortic arch;
Endovascular repair;
Hybrid procedures;
Branched stentgrafts

Abstract For aneurysms and dissections involving the aortic arch, the traditional treatment is open surgical repair requiring cardiopulmonary bypass and deep hypothermic circulatory arrest. Reported mortality rates range from 7% to 17% and neurologic injury rates range from 4% to 12%. Since the first clinical applications of endovascular repair in the early 1990s, this less-invasive treatment modality has evolved steadily. For the treatment of aortic arch pathologies, combined open and endovascular strategies (hybrid procedures) have gained a widespread implementation. Evidence to date proves the feasibility of open surgical branch re-vascularisation followed by endovascular repair into the proximal arch. For hybrid procedures, mortality and stroke rates are given as 0–20%, and 0–8%, respectively. Alternative approaches using fenestrated and branched stent grafts have been considered. Although this technique is challenging and devices are not available widely, it is anticipated that this new technique will expand the range of aortic arch pathologies that can be treated by endovascular means.

Table 1 Results with frozen elephant trunk procedures

Author	Year	Mortality	Stroke	Spinal cord injury
Di Bartolomeo et al.	2009	2/34 (6%)[a]	0/34 (0%)	3/34 (9%)
Shimamura et al.	2008	4/126 (3.2%)[b]	7/126 (5.6%)	8/126 (6.4%)
Baraki et al.	2007	5/39 (12.8%)[a]	5/39 (12.8%)	0/39 (0%)
Liu et al.	2006	2/60 (3.3%)[a]	3/60 (5.0%)	1/60 (1.6%)
Uchida et al.	2006	2/35 (5.7%)[b]	0/35 (0%)	0/35 (0%)
Flores et al.	2006	3/25 (12%)[a]	4/25 (16%)	6/25 (24%)
Total		18/319 (5.6%)	19/319 (6.0%)	18/319 (5.6%)

[a] = inhospital mortality.
[b] = 30-day mortality.

Table 2 Results after hybrid arch procedures including landing zones 0 and 1

Author	Year	Mortality	Stroke	Spinal cord injury	EL Ia
Weigang et al.	2009	4/26 (15.4%)	0/26 (0%)	0/26 (0%)	0/26 (0%)
Melissano et al.	2007	2/26 (7.7%)	2/26 (7.7%)	0/26 (0%)	5/26 (19,2%)
Czerny et al.	2007	2/27 (7.4%)	0/27 (0%)	0/27 (0%)	4/27 (14,8%)
Bergeron et al.	2006	2/25 (8%)	2/25 (8%)	1/25 (4%)	3/25 (12%)
Saleh et al.	2006	0/15 (0%)	0/15 (0%)	0/15 (0%)	0/15 (0%)
Schumacher et al.	2006	5/25 (20%)	1/25 (4%)	0/25 (0%)	3/25 (12%)
Total		15/144 (10.4%)	5/144 (3.5%)	1/144 (0.7%)	15/144 (10.4%)

EL Ia = endoleak at proximal landing zone.

Results of Endografting of the Aortic Arch in Different Landing Zones

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Introduction. *Endovascular approach to the aortic arch is an appealing solution for selected patients. Aim of this study is to compare the technical and clinical success recorded in the different anatomical settings of endografting for aortic arch disease.*

Methods. *Between June 1999 and October 2006, among 178 patients treated at our Institution for thoracic aorta disease with a stent-graft, the aortic arch was involved in 64 cases. According to the classification proposed by Ishimaru, aortic "zone 0" was involved in 14 cases, "zone 1" in 12 cases and "zone 2" in 38 cases. A hybrid surgical procedure of supraortic debranching and revascularization was performed in 37 cases to obtain an adequate proximal aortic landing zone.*

Results. *"Zone 0" (14 cases). Proximal neck length: 44 ± 6 mm. Initial clinical success 78.6%: 2 deaths (stroke), 1 type Ia endoleak. At a mean follow-up of 16.4 ± 11 months the midterm clinical success was 85.7%. "Zone 1" (12 cases). Proximal neck length: 28 ± 5 mm. Initial clinical success 66.7%: 0 deaths, 4 type Ia endoleaks. At a mean follow-up of 16.9 ± 17.2 months the midterm clinical success was 75.0%. "Zone 2" (38 cases) Proximal neck length: 30 ± 5 mm. Initial clinical success 84.2%: 2 deaths (1 cardiac arrest, 1 multiorgan embolization), 3 type Ia endoleaks, 1 case of open conversion. Two cases of delayed transitory paraparesis/paraplegia were observed. At a mean follow-up of 28.0 ± 17.2 months the midterm clinical success was 89.5%.*

Conclusions. *Total debranching of the arch for "zone 0" aneurysms allowed to obtain a longer proximal aortic landing zone with lower incidence of endoleak, however a higher risk of cerebrovascular accident was observed. The relatively high incidence of adverse events in "zone 1" could be associated to a shorter proximal neck, therefore this landing zone is reserved for patients unfit for sternotomy. In case of endoleak, discovered after a satisfactorily positioned endograft in the arch, the rate of spontaneous resolution within the first 6 months is high.*

Melissano G, et al. Eur J Vasc Endovasc Surg. 2007 May;33(5):561-6

Results in the Different Proximal Aortic Landing Zones

	Zone "0" $n=14$	Zone "1" $n=12$	Zone "2" $n=38$	Total $n=64$	*P*
Technical success	13 (92.9%)	8 (66.7%)	34 (89.5 %)	55 (85.9%)	NS*
Type I or III endoleak	1 (7.1%)	4 (33.3%)	3 (7.9%)	8 (12.5%)	NS*
Intraoperative death	0	0	1 (2.6%)	1 (1.6%)	NS*
Procedural open conversion	0	0	0	0	NS*
30-days mortality	2 (14.3%)	0	2 (5.3%)	4 (6.3%)	NS*
Paraparesis/paraplegia	0	0	2 (5.3%)	2 (3.1%)	NS*
Stroke	2 (14.3%)	0	0	2 (3.1%)	NS*
Renal failure	0	0	1 (2.6%)	1 (1.6%)	NS*
Respiratory failure	1 (7.1%)	0	0	1 (1.6%)	NS*
ICU stay	3 (1–7) days	1 (0–2) days	0 (0–1) days	0 (0–2) days	<.0001**
Length hospital stay	9 (6–11) days	6 (5–8) days	4 (3–5) days	5 (4–7) days	<.0001**
Initial clinical success	11 (78.6%)	8 (66.7%)	32 (84.2%)	51 (79.7%)	NS*
30-days open conversion	0	0	1 (2.6%)	1 (1.6%)	NS*
Short term clinical success	12 (85.7%)	11 (91.7%)	35 (92.1%)	58 (90.6%)	NS*
Resolution postoperative type I endoleak	1 (7.1%)	3 (25.0%)	3 (7.9%)	7 (18.4%)	NS*
Mid term clinical success	12 (85.7%)	9 (75.0%)	34 (89.5%)	55 (85.9%)	NS*
New onset type I or III endoleak	0	0	0	0	NS*
Aneurysm related deaths	0	2 (16.7%)	0	2 (3.1%)	NS*
Open conversion	0	0	1 (2.6%)	1 (1.6%)	NS*

*Chi-square test or the Fisher Exact test; **Kruskal-Wallis test.

Summary

- Conventional open surgical aortic arch replacement can be performed in with excellent early and long term results
- The early results of various hybrid endovascular arch procedures are comparable but definitely shows inferior long term outcomes
- Hybrid endovascular procedures should be limited to extensive aortic arch surgery that may be difficult to do in one stage
- Old aged patients with limited life expectancy are good candidates for endovascular procedure
- Due to the relatively inferior event free survival, hybrid endovascular arch procedure should not be the first choice surgery in young patients

Thank you for your attention!