



Will we face a big problem with the aortic valve/root after ASO ?

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Centre de Référence Maladies Rares
Malformations **C**ardiaques **C**ongénitales **C**omplexes-M3C
CARDIOGEN



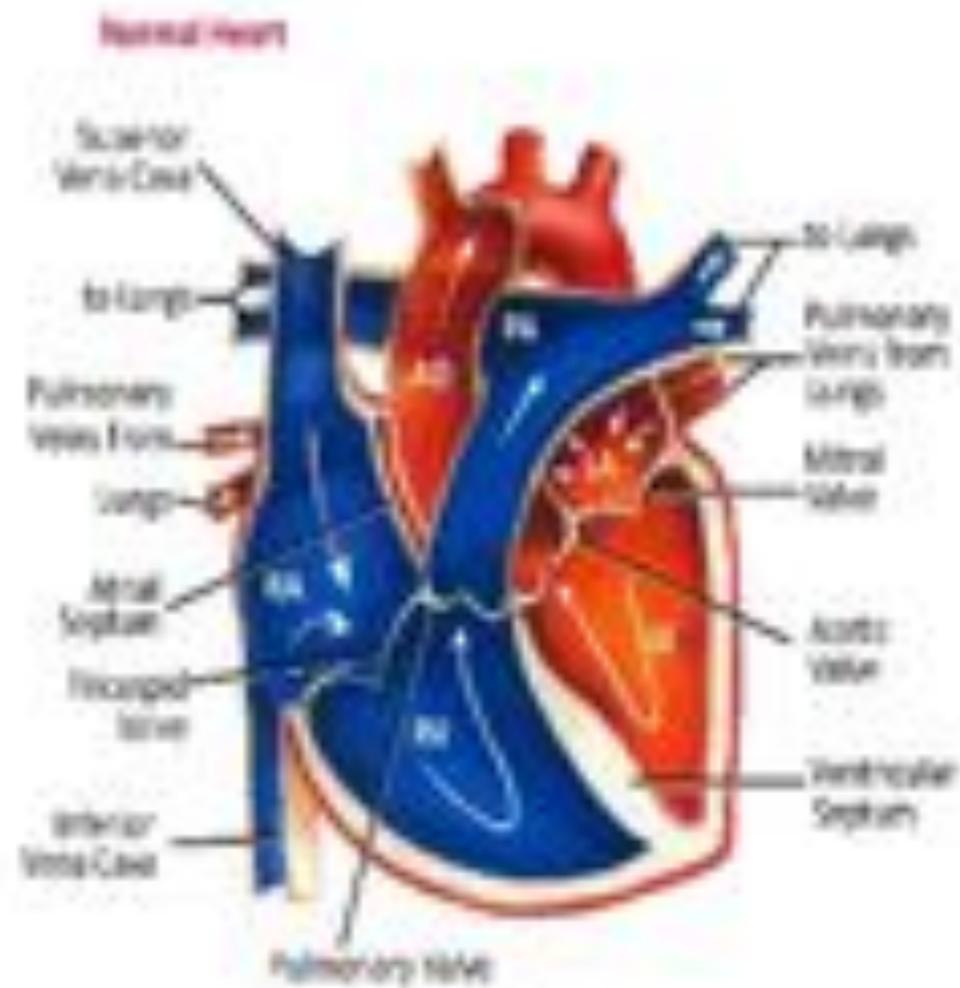
European Reference Network
for rare or low prevalence complex diseases
Network Respiratory Diseases (ERN-LUNG)



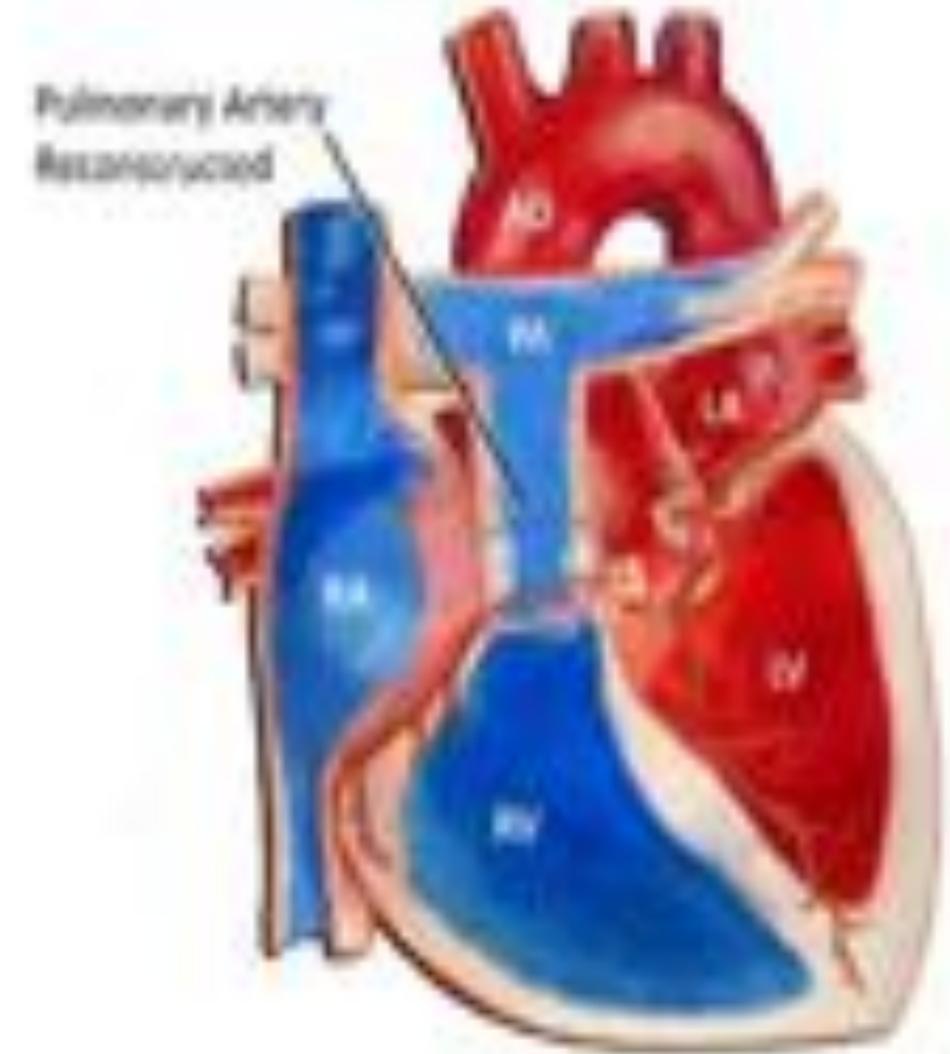
European Reference Network
for rare or low prevalence complex diseases
Network Heart Diseases (ERN GUARD-HEART)

Transposition of the great arteries

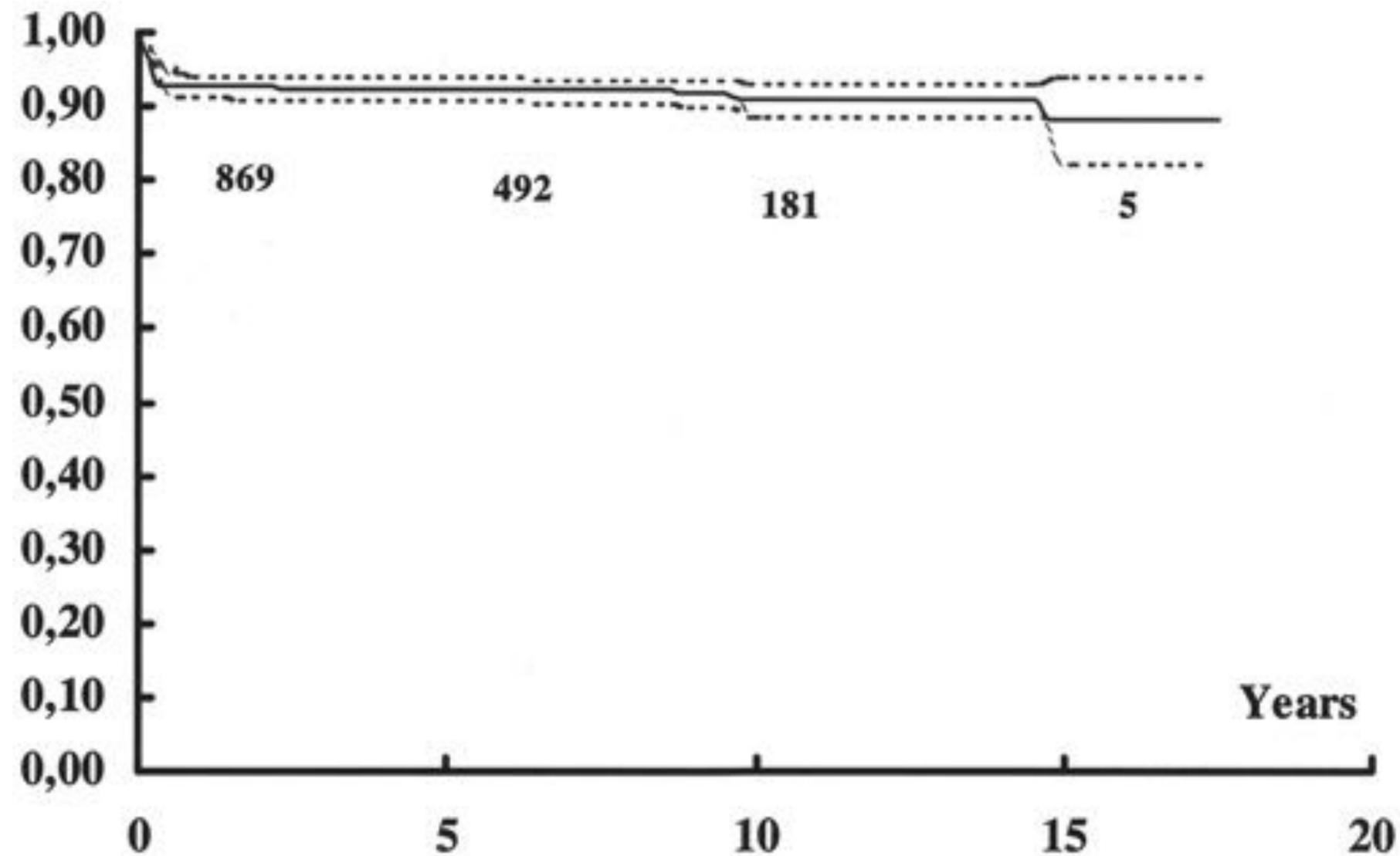
Arterial Switch Operation



**Transposition of the Great Arteries:
The Arterial Switch Operation**



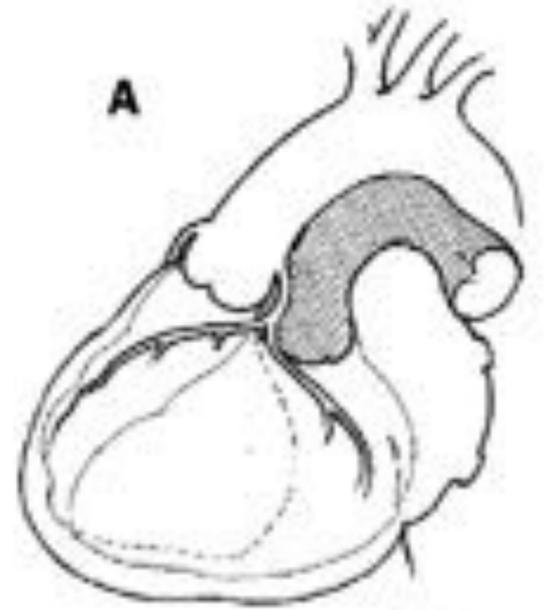
Actuarial survival free of coronary events for 1304 patients



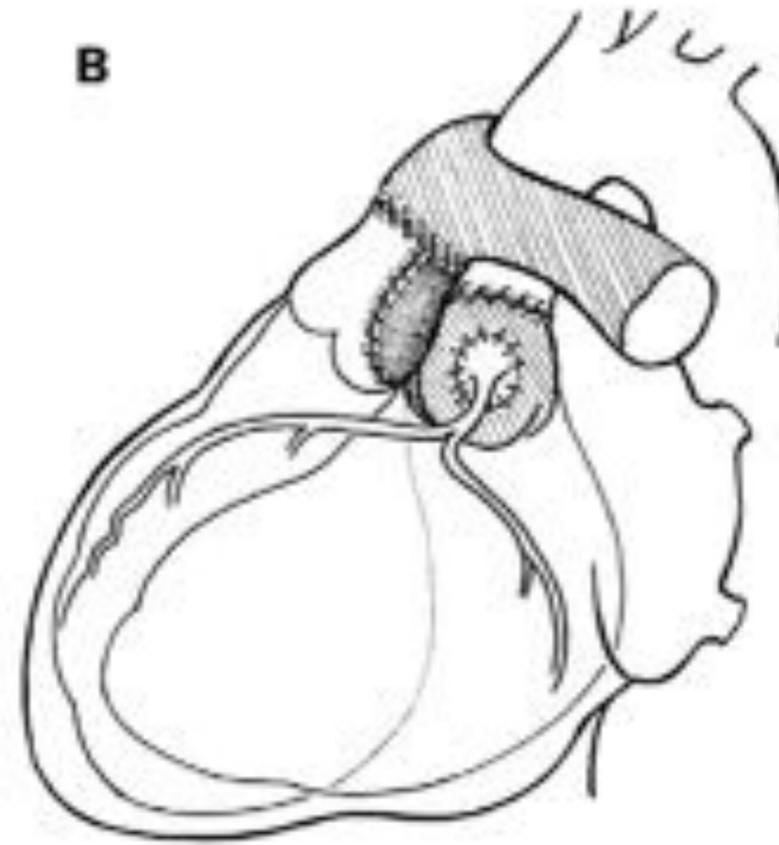
Legendre, A. et al. Circulation 2003;108:II-186-II-190

Arterial Switch Operation (ASO): surgical technique

TGA

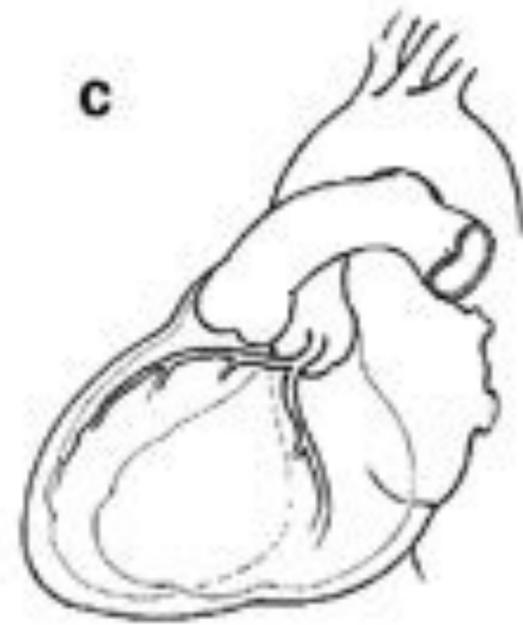


B



ASO

C

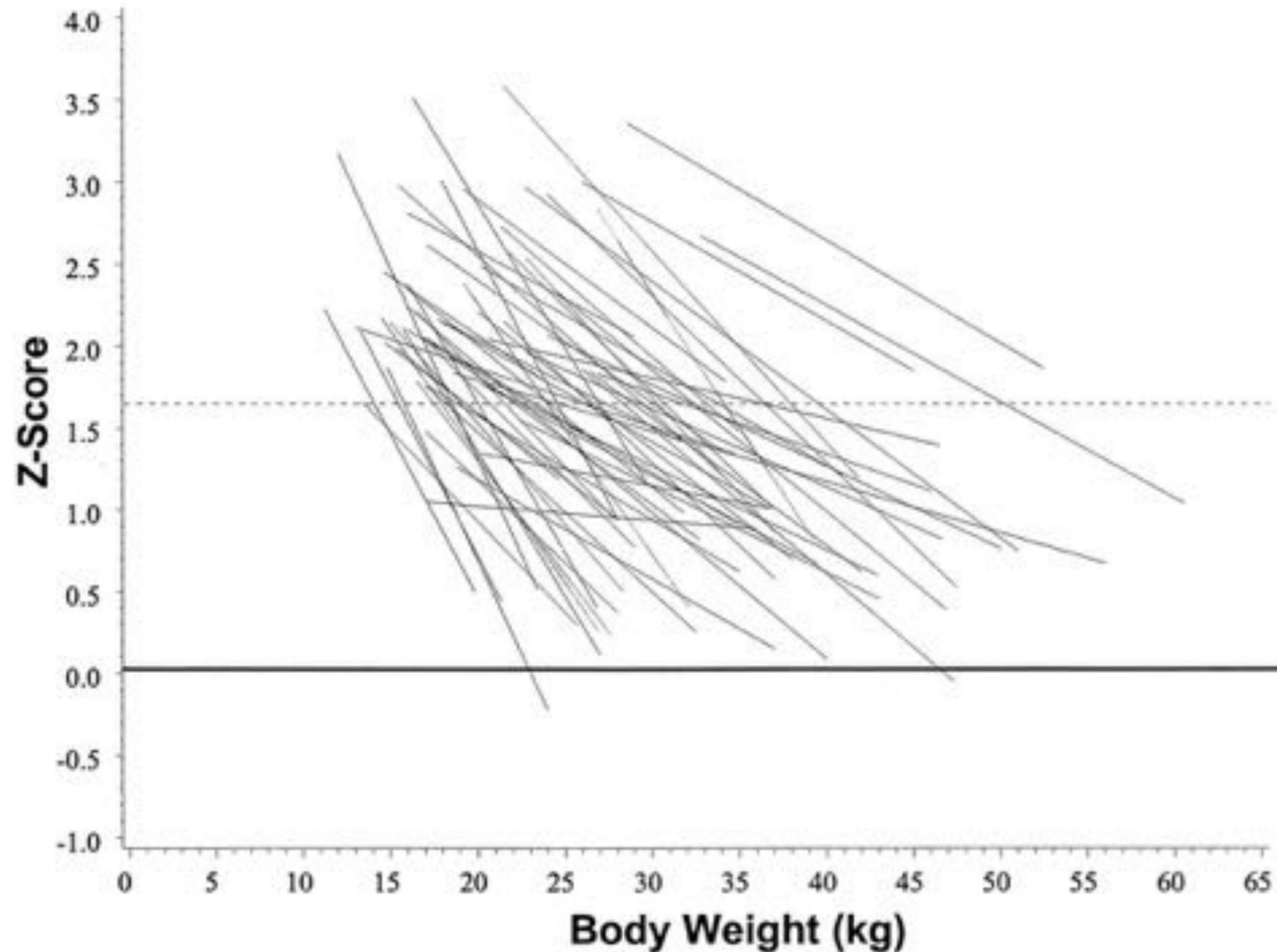


Normal heart

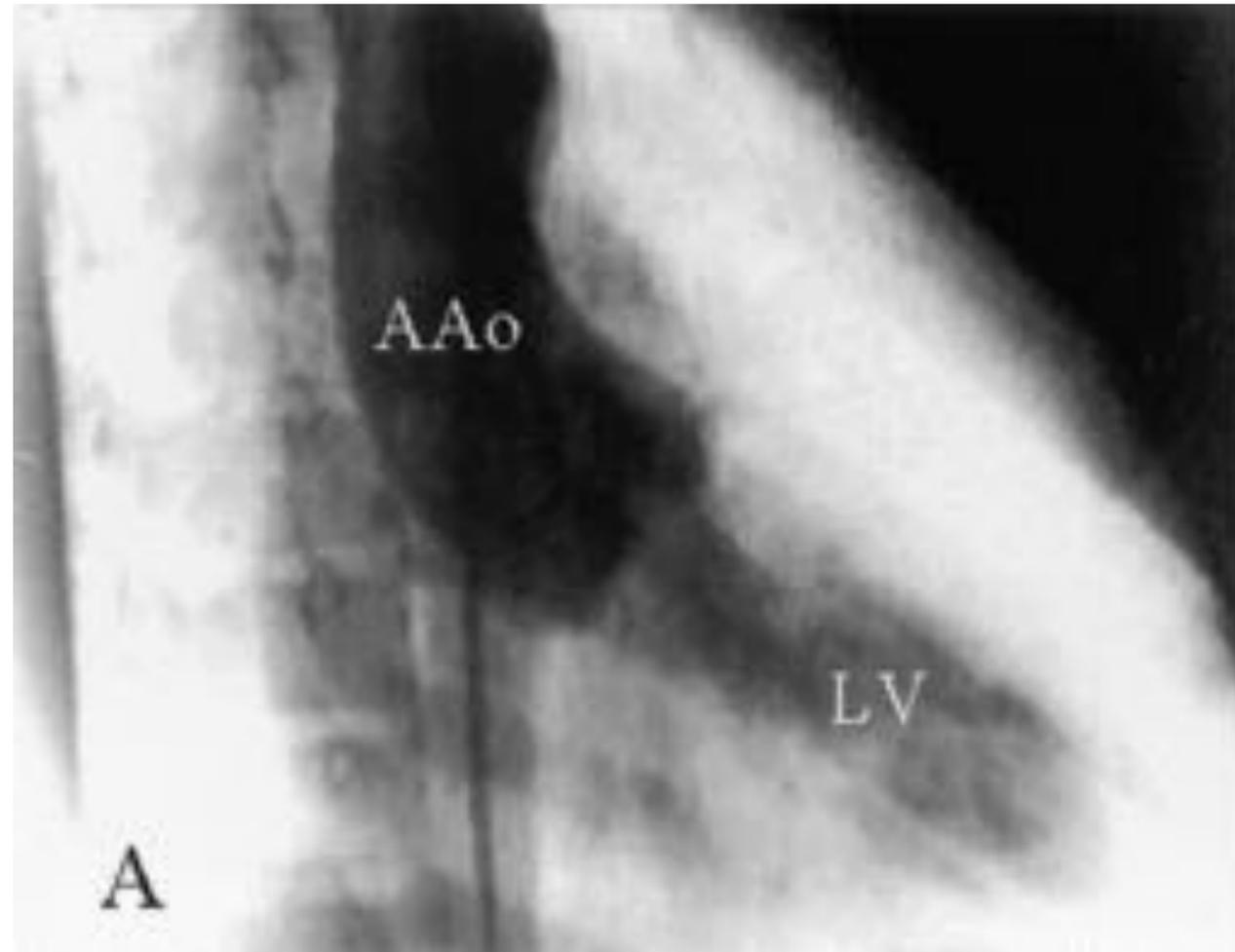
Aortic Root

- After ASO Neo-aortic valve and sinus are larger than normal.
- First year of life : rapid dilatation of the new aorta
- Further : active growth with tendency towards normalization of the valve and sinus size.

Echocardiographic end-systolic measurements of the neo-aortic root vs body weight
60 children (solid lines) after neonatal ASO
mean age 5.3 {+/-} 1.6 years and mean age 10.5 {+/-} 1.6 years



Morphology of the reconstructed Aorta: risk factor for Aortic regurgitation



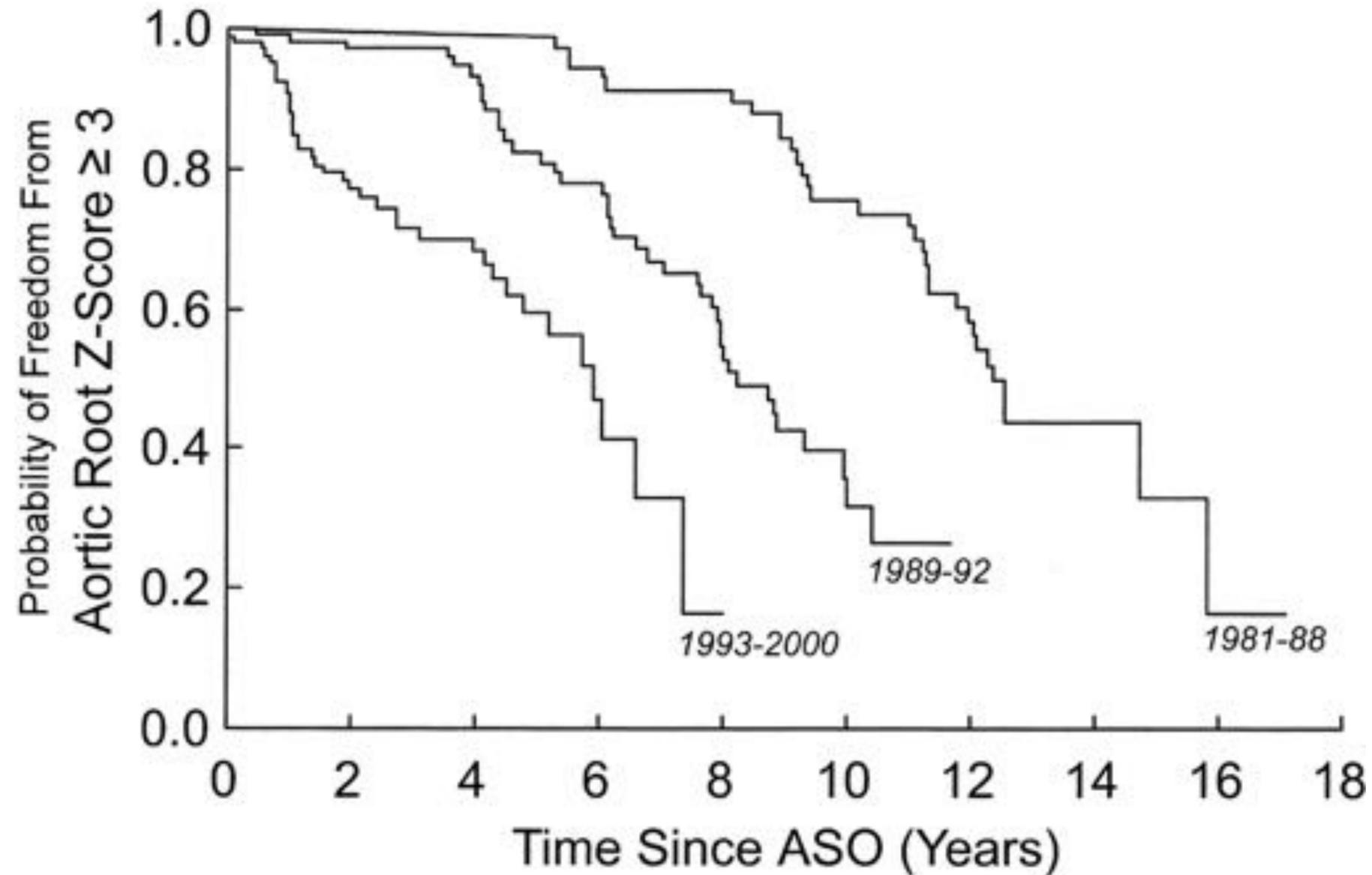
More AR



No AR

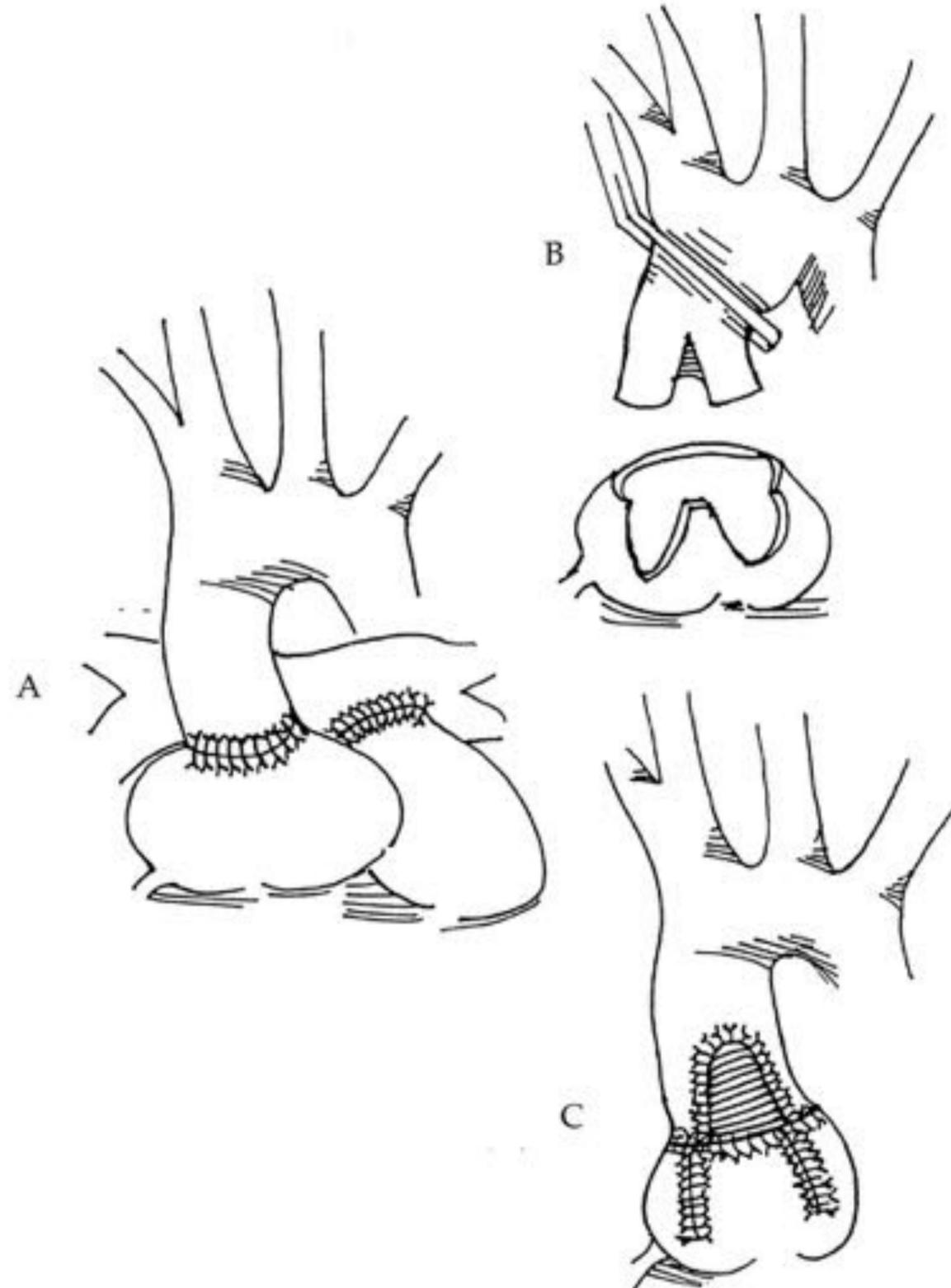
Freedom from aortic root dilation over time since ASO

3 time periods : 1981 to 1988, 1989 to 1992, and 1993 to 2000 ($P < 0.001$)

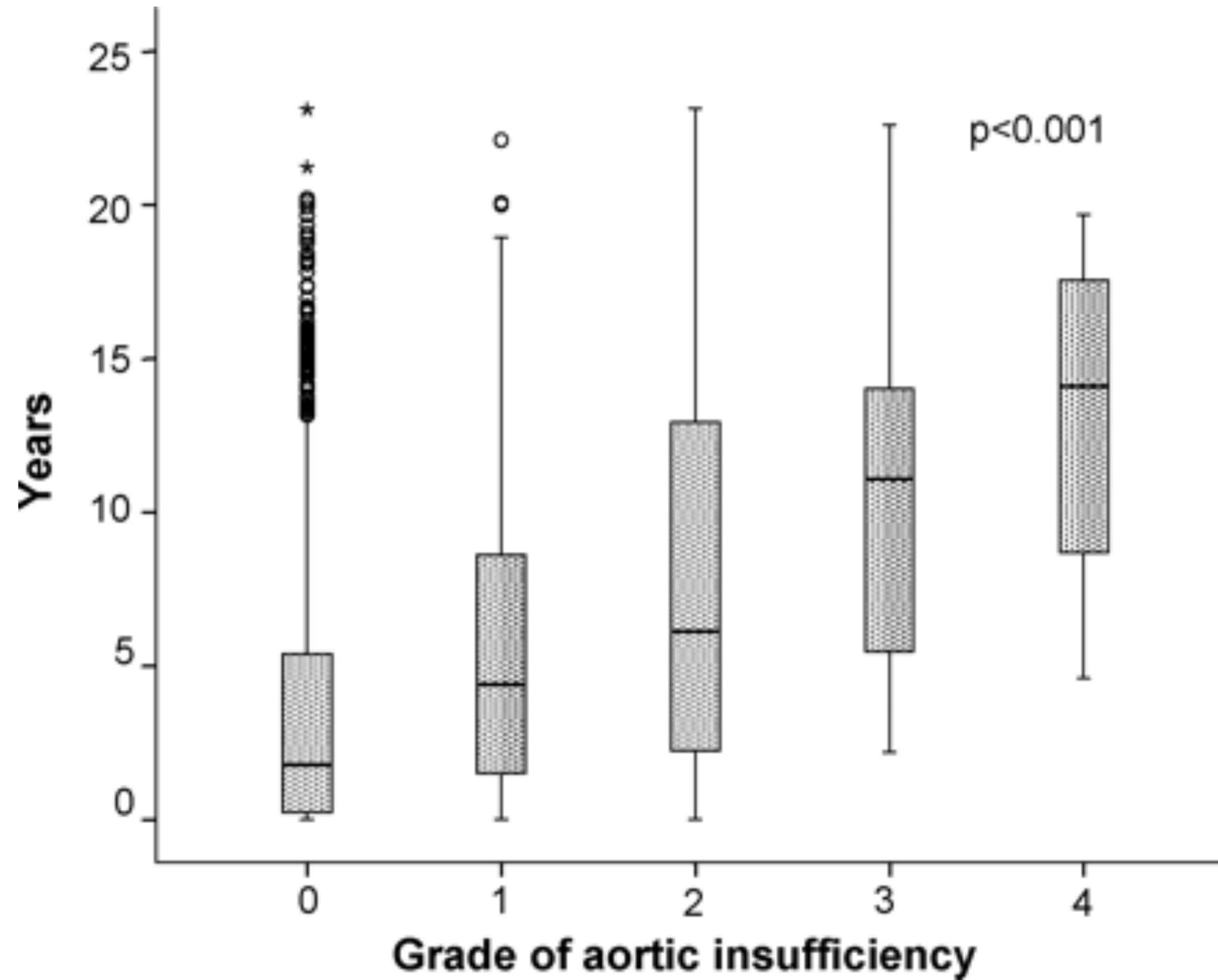


Schwartz, M. L. et al. *Circulation* 2004;110:II-128-II-132

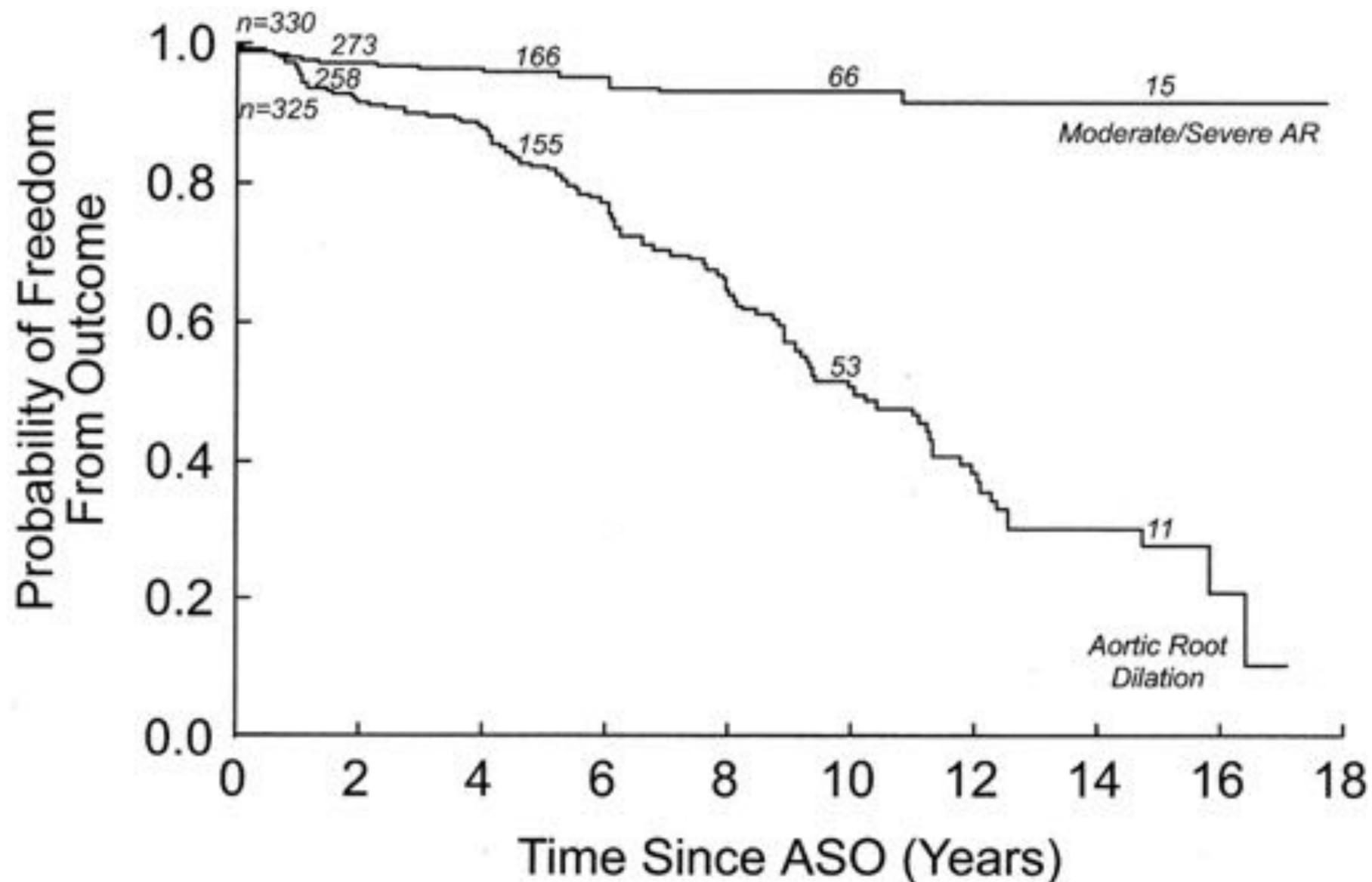
Aortic valve repair for AR after ASO ?



Development of Aortic Insufficiency over time



Freedom from neo-aortic root dilation (neo-aortic root z-score ≥ 3.0) and probability from at least moderate neo-aortic regurgitation



Schwartz, M. L. et al. *Circulation* 2004;110:II-128-II-132

Previous risk factors for Aortic root dilatation and aortic valve regurgitation

- ventricular septal defect
- pulmonary artery banding
- aortic/pulmonary artery mismatch
- postoperative geometry of aortic root

Neoaortic valve regurgitation

- Underestimated complication of anatomic repair of TGA.
- Anatomic pulmonary valve (thin leaflets, little collagen and elastic tissue) : neoaortic valve after ASO.
- Mild regurgitation : 35% of patients
- Moderate to severe : 5% patients.
- Frequency of the regurgitation after ASO increases with time
- Isolated cases of valve replacement.
- In our series (review of patients born before 4 AVR done at age (16, 18, 22 , 23)

Long-Term Growth of the Neoaortic Root after Arterial Switch Operation.

Oda S¹, Nakano T², Fujita S², Sakaguchi S², Kado H².

Ⓜ Author information

Abstract

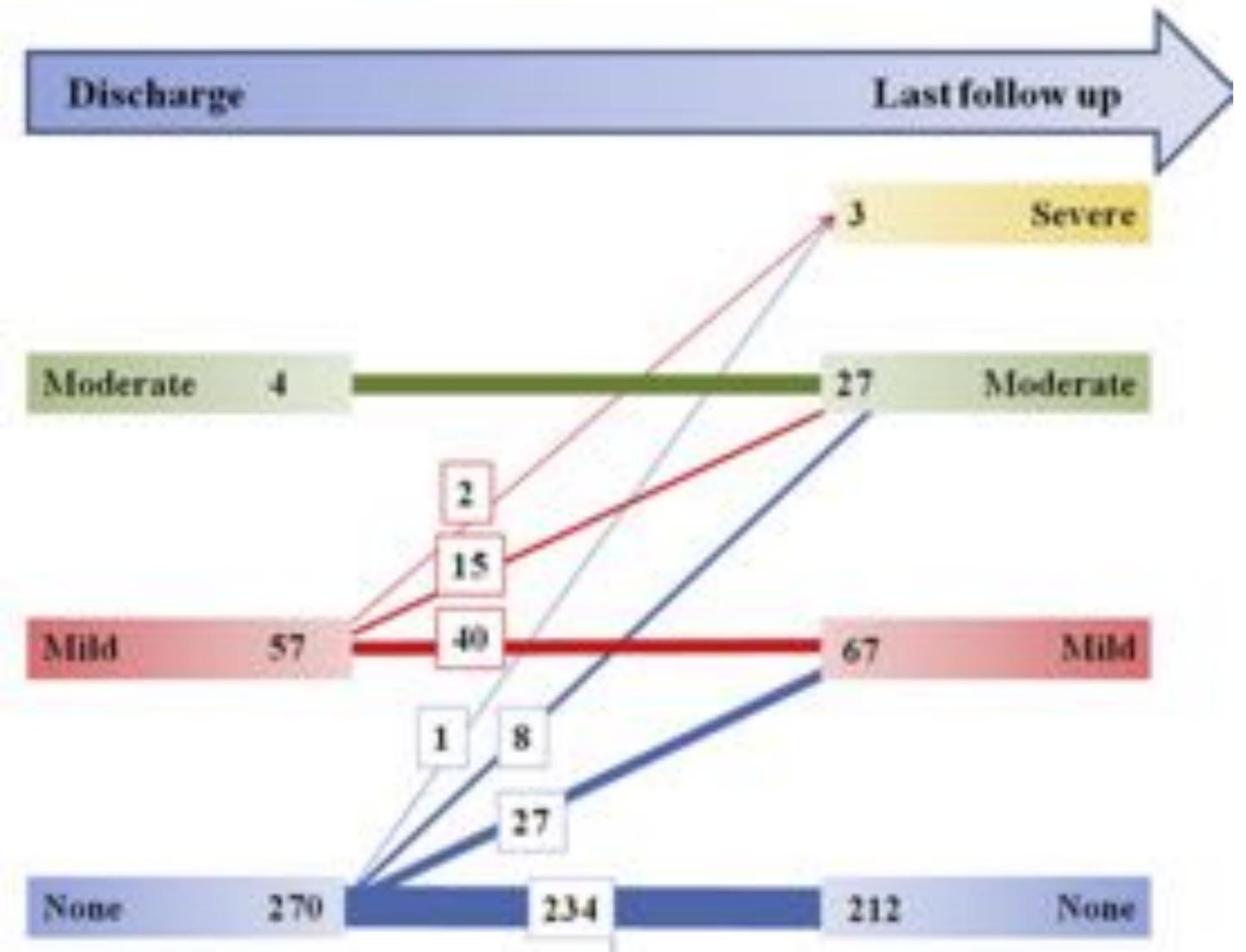
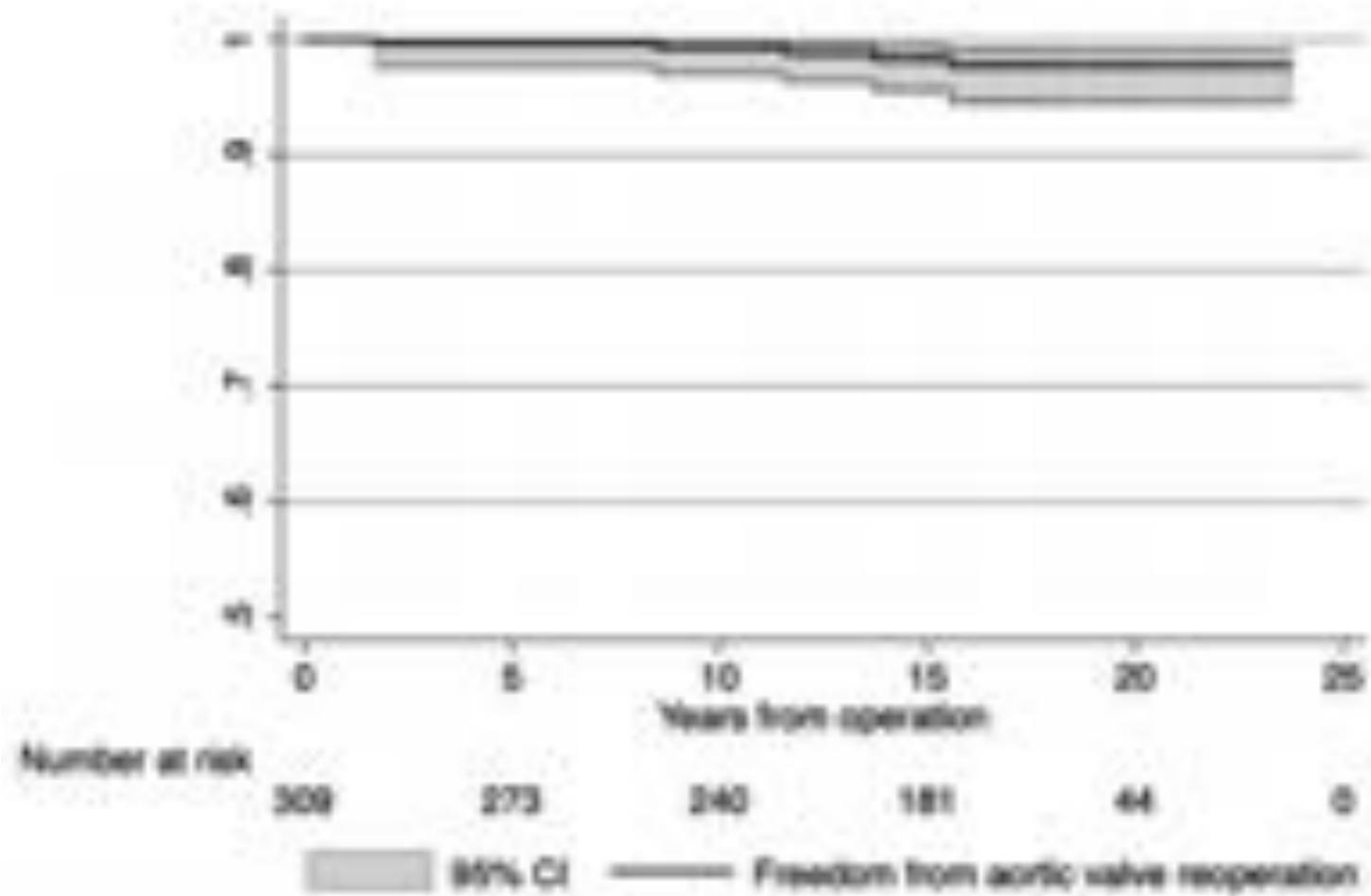
BACKGROUND: The growth of the neoaortic root after the arterial switch operation for the transposition of the great arteries remains unclear. This study aimed to investigate the growth of the neoaortic root and identify risk factors for neoaortic root dilatation.

METHODS: Serial angiographic measurements of the neoaortic root for at least 10 years were evaluated in 145 patients. A total of 1876 measurements of the sinuses of the Valsalva and the neoaortic annuli were obtained. A linear mixed effects model was used for z-score analysis, including evaluation of risk factors for neoaortic root dilatation. To assess changes in the time course of neoaortic root absolute diameters, a nonlinear mixed effects model with a growth curve model was used.

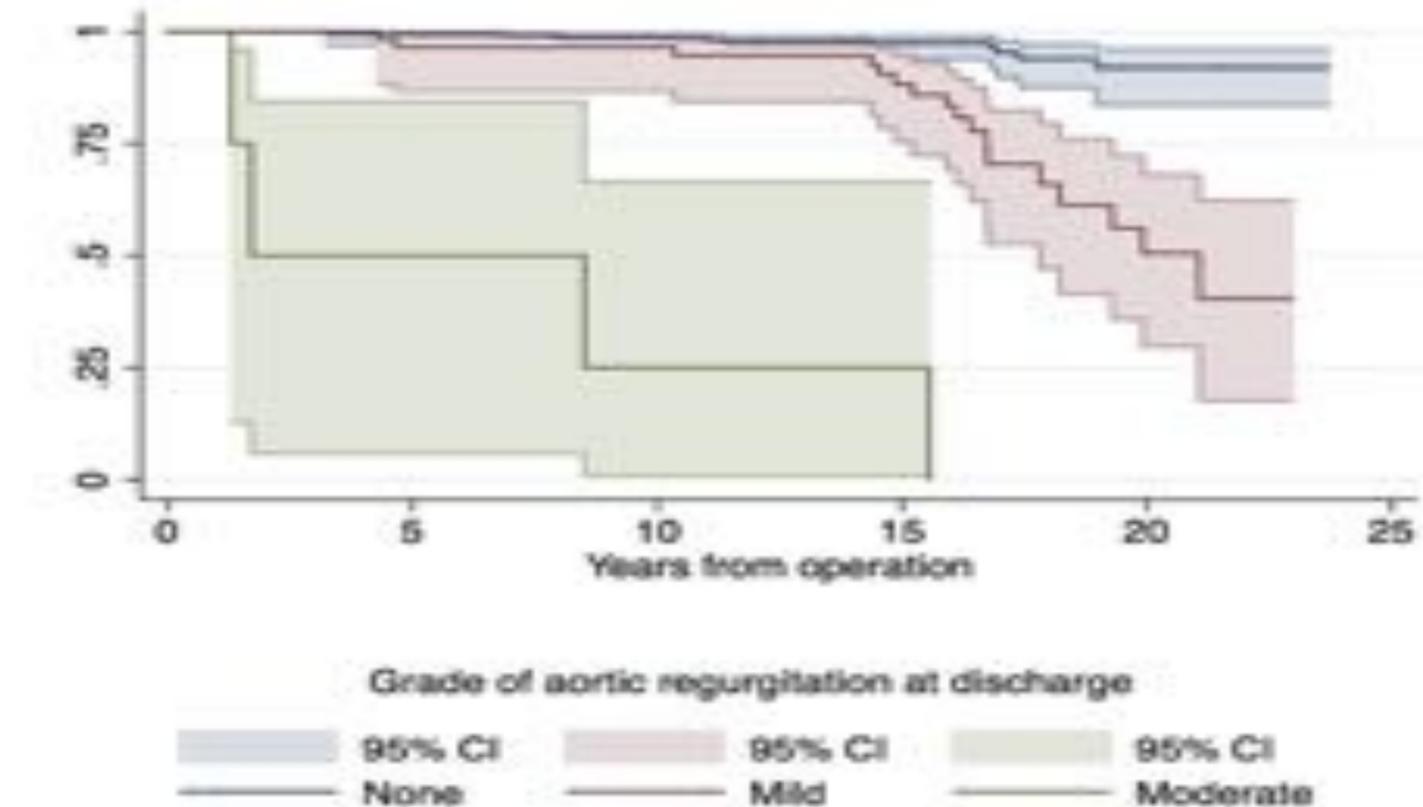
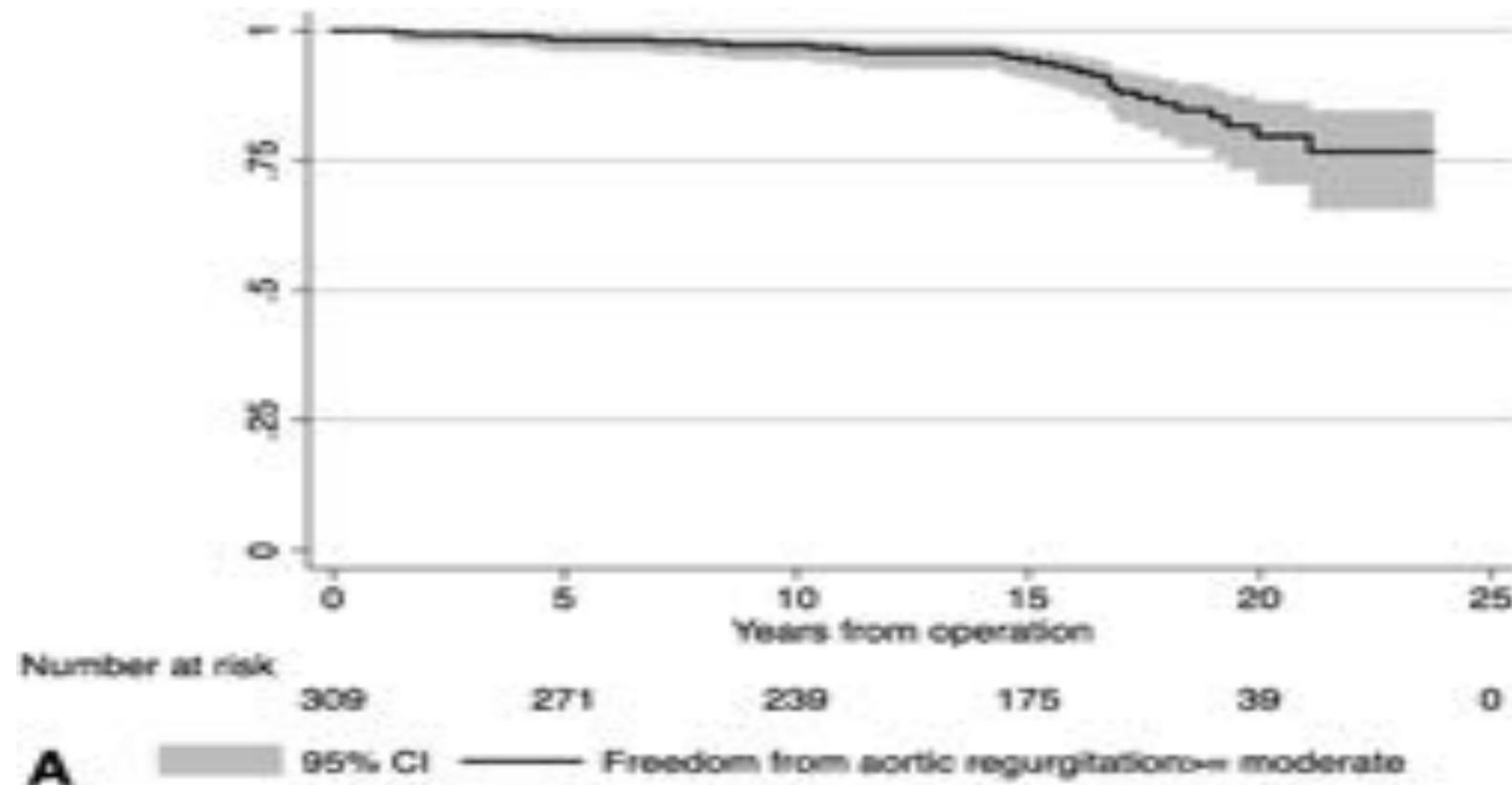
RESULTS: The growth curve revealed progressive growth of the neoaortic root during somatic growth and stabilization in adulthood without normalization. The growth rates of the sinus and annulus were 0.0046 and 0.029 z-score per year, respectively. The sinus and annulus were estimated to grow up to 47 ± 1 mm and 31 ± 1 mm, respectively. Major risk factors for neoaortic root dilatation were double-outlet right ventricle (parameter estimate [PE]=2.1; 95% confidence interval [CI]=1.5 to 2.7; $P < .0001$ for sinus, PE=1.2; 95%CI=0.7 to 1.6; $P < .0001$ for annulus) and presence of neoaortic valve insufficiency (PE=0.9; 95%CI=0.4 to 1.5; $P < .001$ for sinus, PE=1.6; 95%CI=1.2 to 2.0, $P < .0001$ for annulus).

CONCLUSIONS: The risk for neoaortic root dilatation was common. Long-term surveillance is mandatory, particularly in patients with double outlet right ventricle and neoaortic valve insufficiency.

Long-term fate of the aortic valve after ASO

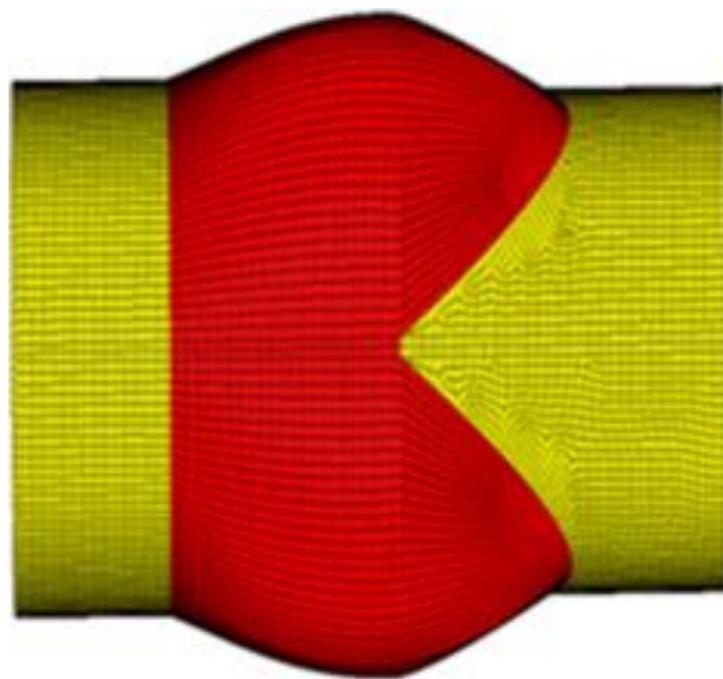
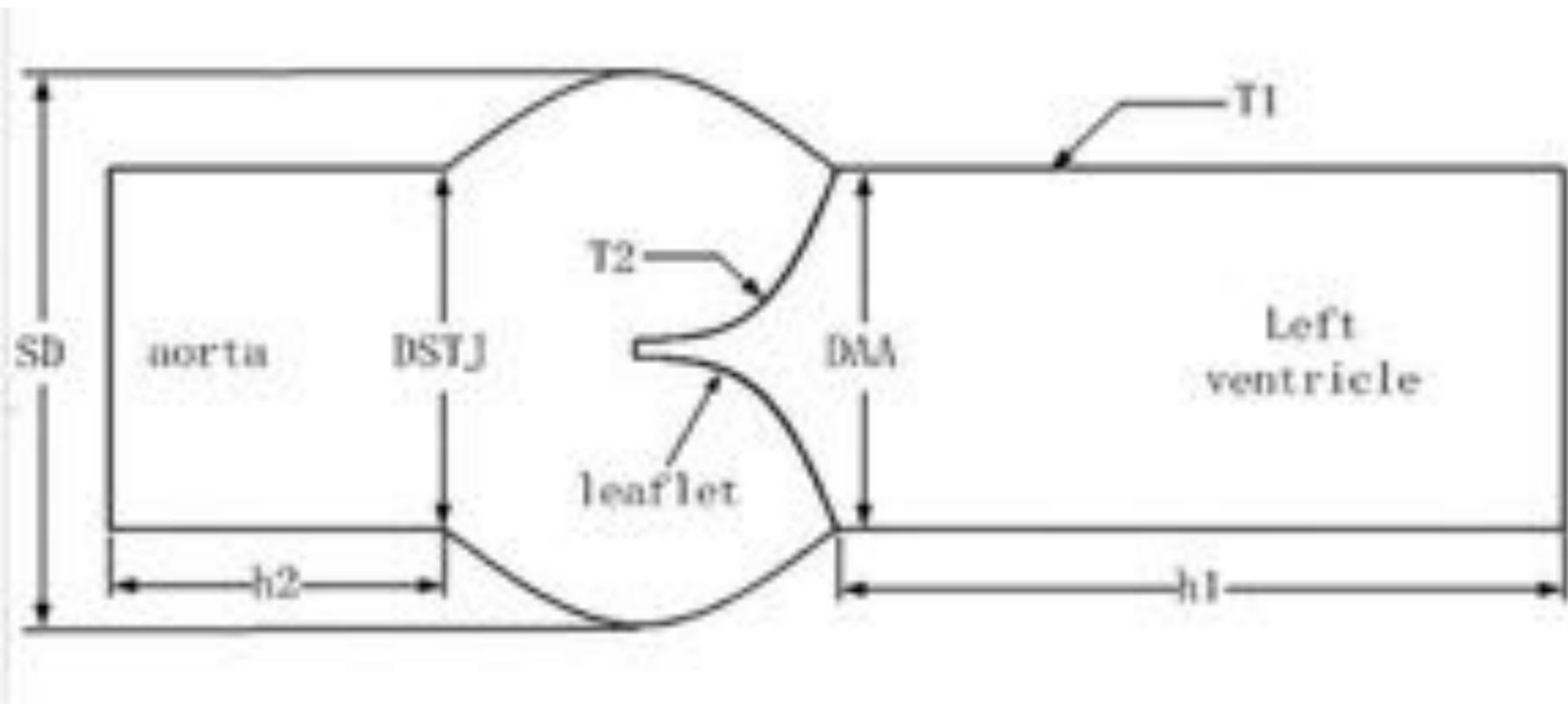


Long-term fate of the aortic valve after ASO

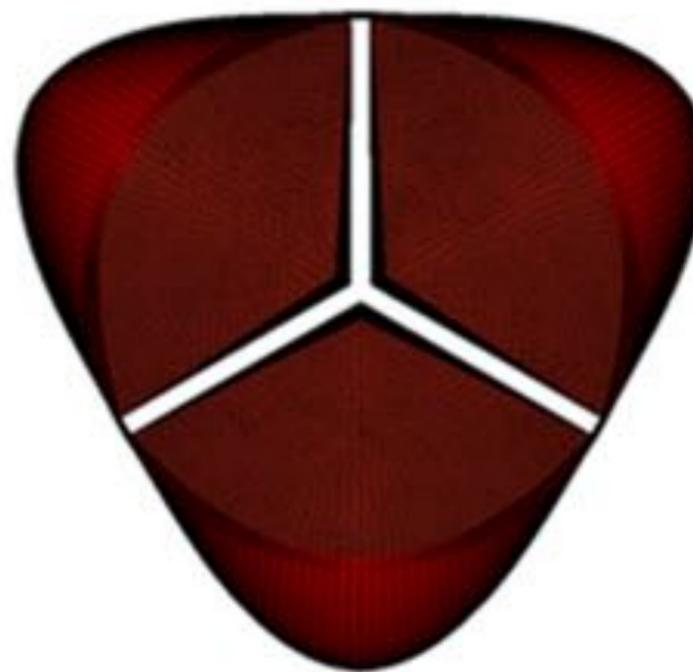


362 patients

Aortic valve surgery in 5 patients, giving freedom from aortic surgery of 99.3% and 97.7% at 10 and 20 years,



a



b

Change of the aortic annulus diameter (CAAD)

Model	DSTJ (mm)	DS (mm)	CAAD (mm)	Relative difference
A	9.70	12.30	1.94E-02	0%
B	11.60	12.30	1.64E-02	-15.46%
C	7.76	12.30	2.42E-02	24.74%
D	9.70	14.76	1.66E-02	-14.43%
E	9.70	9.84	8.85E-03	-54.38%

Pregnancy Outcomes in Women With Transposition of the Great Arteries After an Arterial Switch Operation

- 25 pregnancies /15 women
- 8 women: 1 pregnancy, 7 multiparous.
- No adverse maternal cardiac events.
- Five women (36%) had mild neo-aortic root dilatation pre-pregnancy, but none developed progressive dilatation in the first year post-partum
- Stoll et al. JAMA Cardiol. 2018;3



Pliable bicuspid and tricuspid valves: 232 patients



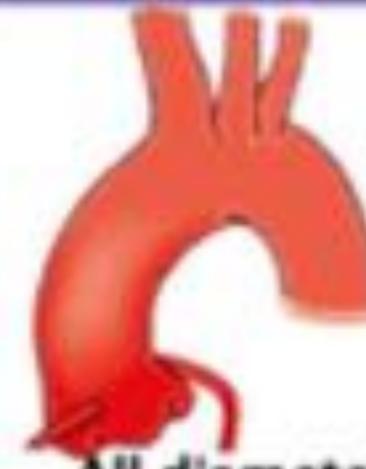
Aortic root aneurysm
149 patients

Valsalva > 45 mm



Supracoronary aorta aneurysm
21 patients

Valsalva < 40 mm



Isolated aortic insufficiency
62 patients

All diameters < 40 mm

Standardized approach according to phenotypes



Remodeling + subvalvular annuloplasty



Supracoronary graft + subvalvular annuloplasty (annulus > 25 mm)



Double sub- and supra-valvular annuloplasty (annulus > 25 mm)

Cusp repair



Alignment of the cusp free edges



Resuspension of cusp effective height



Subvalvular external aortic ring annuloplasty

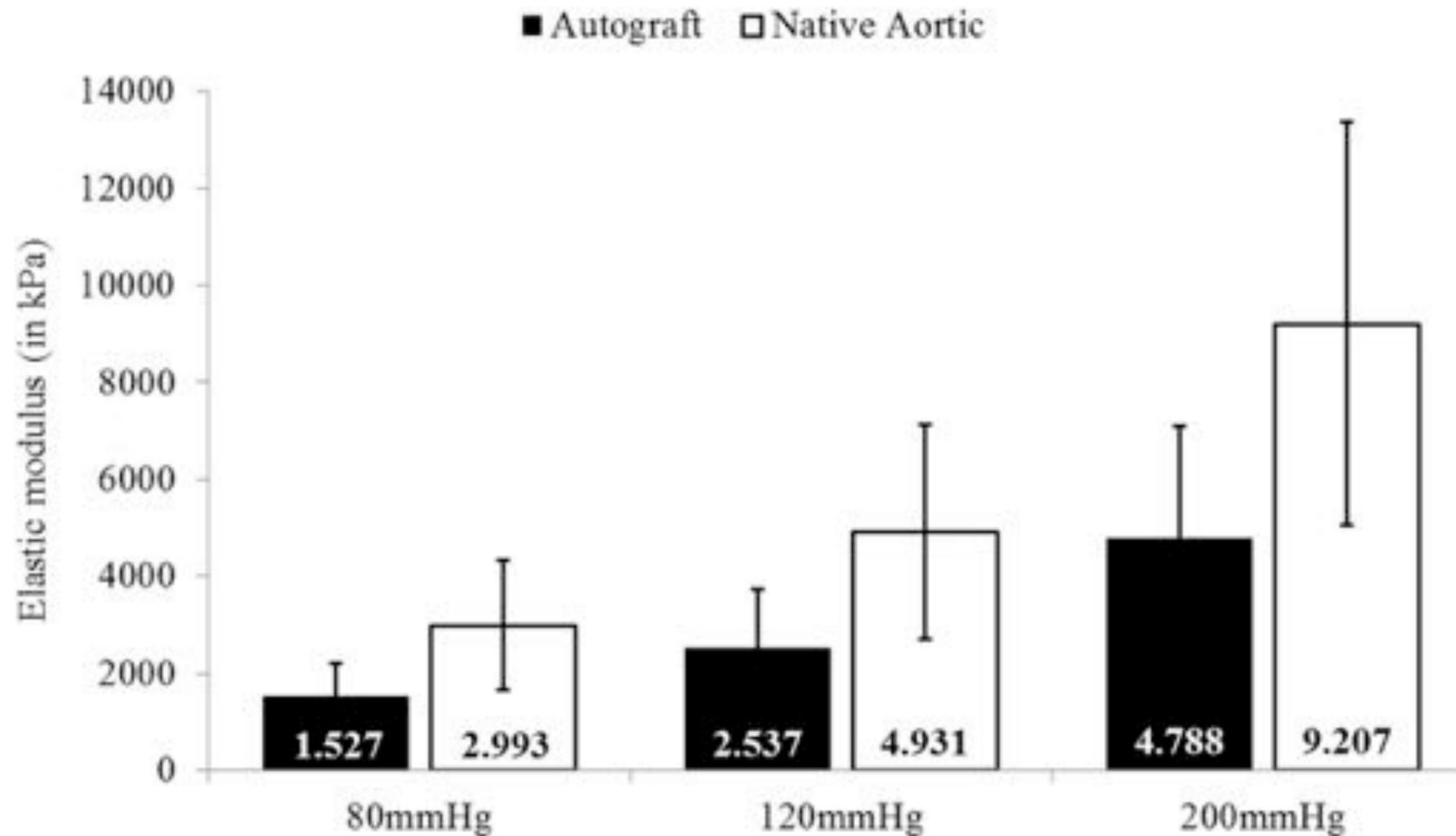


Long-term results of external aortic ring annuloplasty for aortic valve repair†

Eur J Cardiothorac Surg. 2016;50(2):350-360. doi:10.1093/ejcts/ezw070

Eur J Cardiothorac Surg | © The Author 2016. Published by Oxford University Press on behalf of the European Association for Cardio-Thoracic Surgery. All rights reserved.

Biomechanics of Failed Pulmonary Autografts Compared to Native Aortic Roots



American guidelines 2018

- Although some degree of neo-aortic valve regurgitation is common, surgery to replace the neo-aortic valve has only rarely been reported.
- Indications for valve replacement should be based on LV size
 - and/or symptoms ‘2014 VHD guideline ‘
- The more common concern is dilation of the neo-aortic root with preserved aortic valve competence.
- Valve-sparing root replacement is often considered in such cases
- but surgical options should be individualized based upon anatomy and changes
- There are not data to support a specific aortic diameter beyond which the risk of dissection or rupture increases sufficiently to warrant prophylactic aortic replacement.

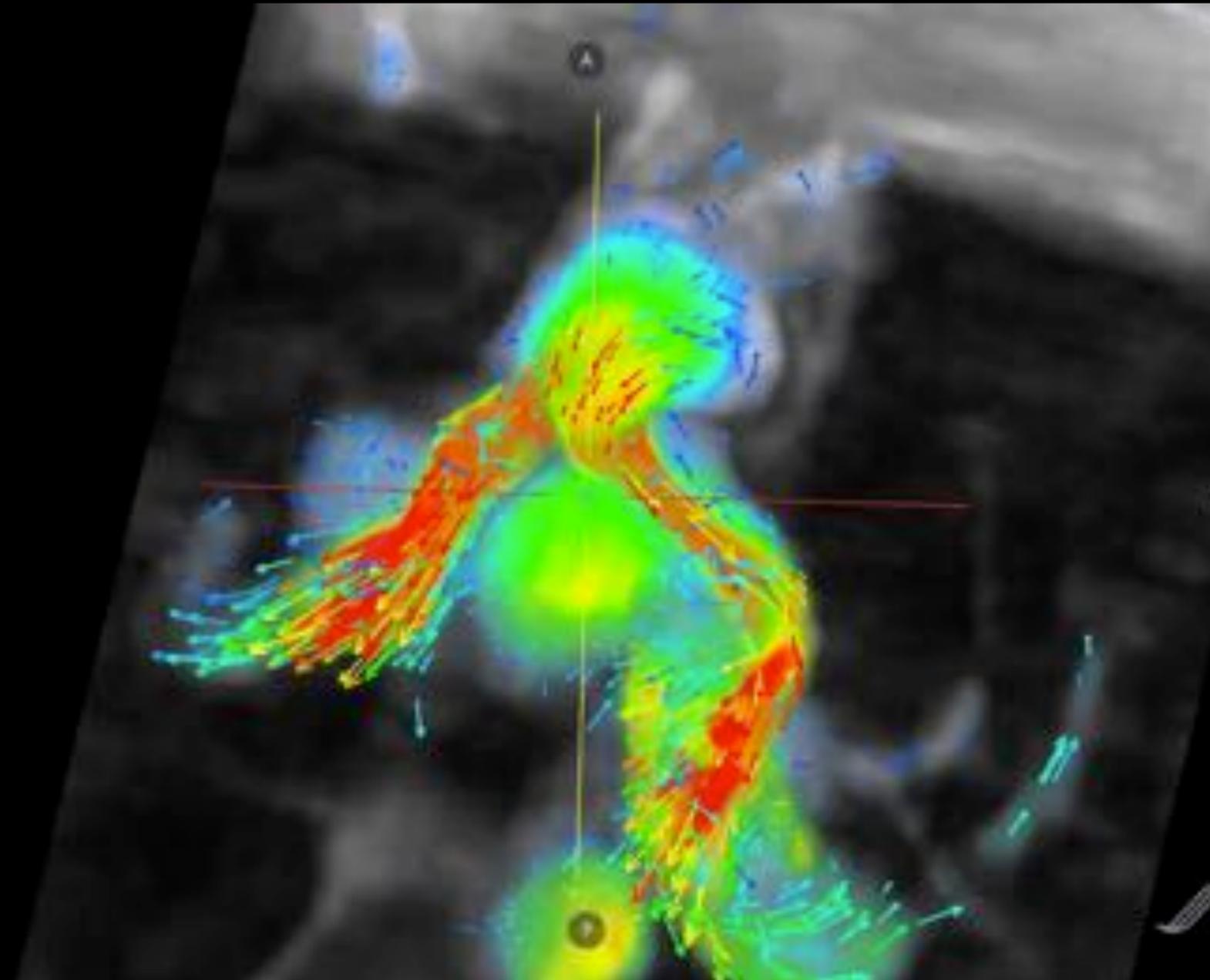
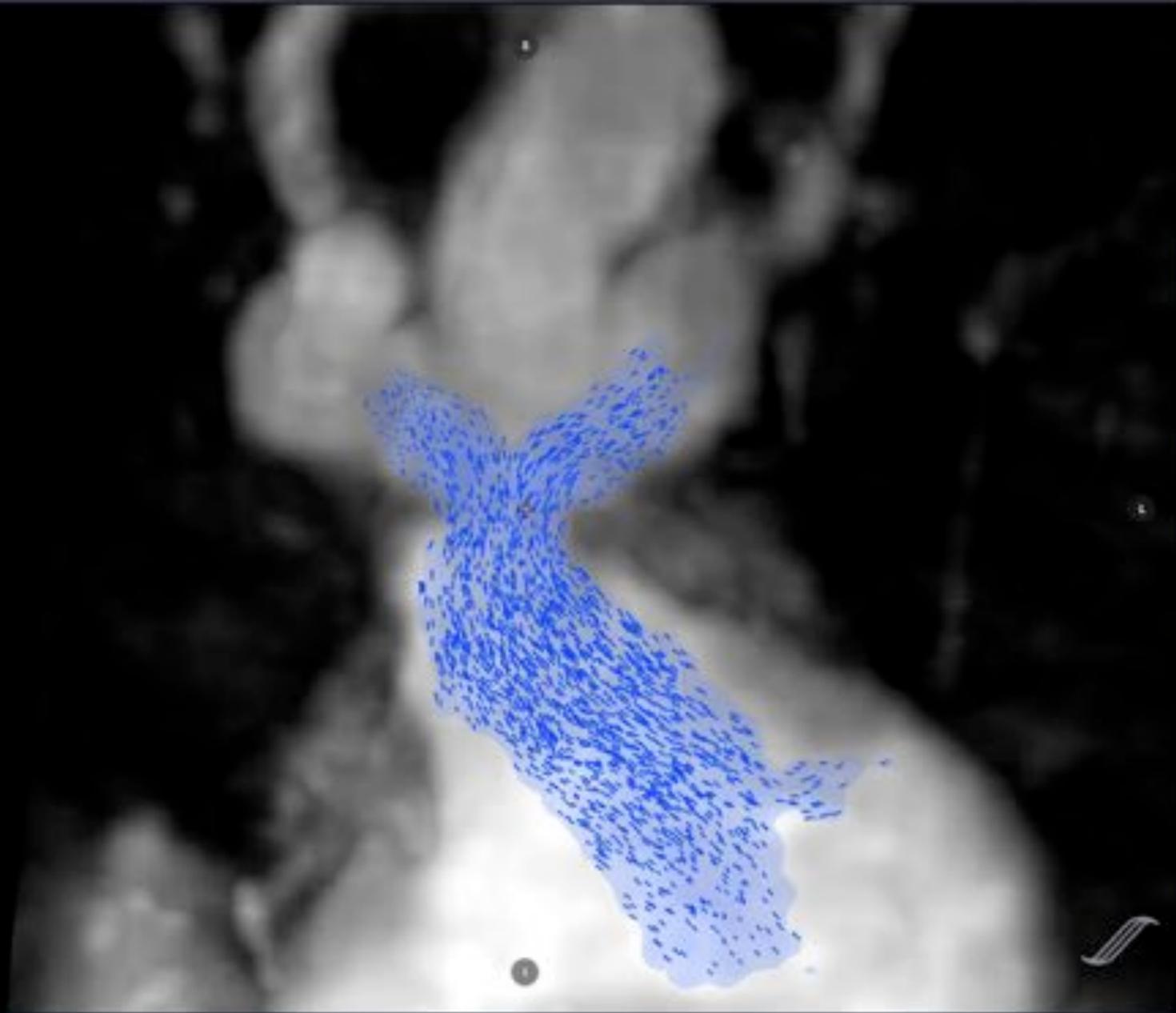
American guidelines 2018

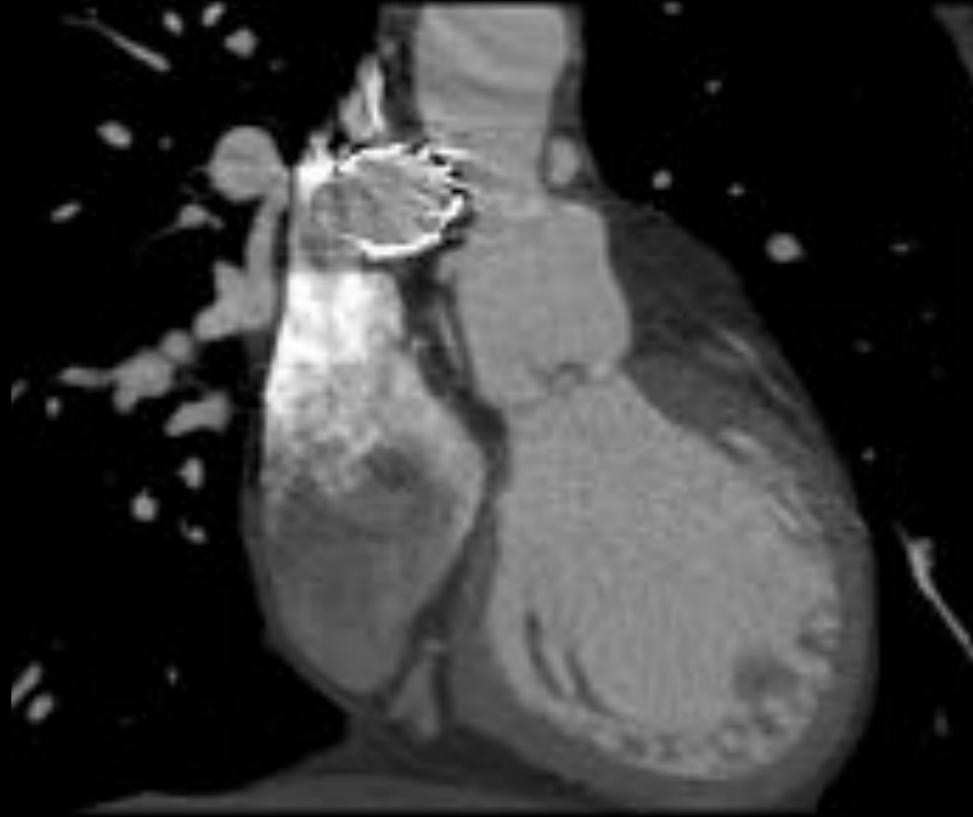
COR	LOE	Recommendations
Diagnostic		
I	C-LD	1) Baseline and serial imaging with either echocardiography or CMR should be performed in adults with d-TGA with arterial switch who have neo-aortic dilation, valve dysfunction or PA or branch PA stenosis or ventricular dysfunction (S4.4.1.2-1–S4.4.1.2-3).
I	C-EO	2) Coronary revascularization for adults with d-TGA with arterial switch should be planned by surgeons or interventional cardiologists with expertise in revascularization in collaboration with ACHD providers to ensure coronary and pulmonary artery anatomy are understood
IIa	B-NR	3) It is reasonable to perform anatomic evaluation of coronary artery patency (catheter angiography, or CT or MR angiography) in asymptomatic adults with d-TGA with arterial switch (S4.4.1.2-4, S4.4.1.2-5).
IIa	C-EO	4) Physiological tests of myocardial perfusion for adults with d-TGA after arterial switch can be beneficial for assessing symptoms suggestive of myocardial ischemia.
IIa	C-EO	5) GDMT is reasonable to determine the need for coronary revascularization for adults with d-TGA after arterial switch (S4.4.1.2-6– S4.4.1.2-8).
Therapeutic		
IIa	C-EO	6) GDMT is reasonable to determine indications for aortic valve replacement in adults with d-TGA after arterial switch with severe neo-aortic valve regurgitation (S4.4.1.2-6).
IIa	C-EO	7) Catheter or surgical intervention for PS is reasonable in adults with d-TGA after arterial switch with symptoms of HF or decreased exercise capacity attributable to PS.

***GDMT guideline-directed management and therapy

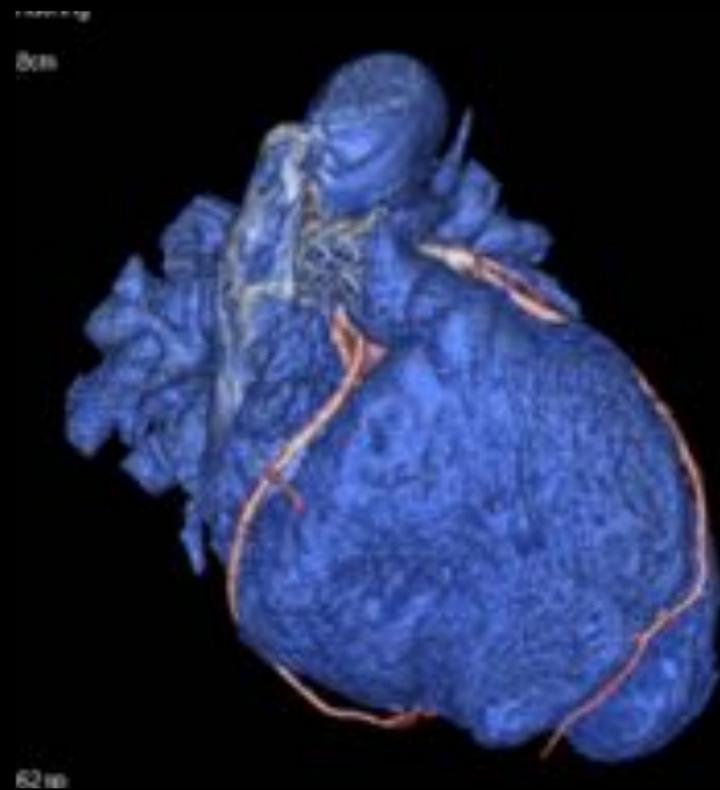
- Coronary reimplantation technique can have a great impact on aortic root geometry and can deform the aortic sinus geometry, predisposing it to later dilatation.
- The trap door technique has been reported to be associated with an increased rate of aortic valve regurgitation.
- We routinely use trap door coronary translocation, but we aim to implant coronary arteries above the sinotubular area when possible, avoiding potential alteration of the aortic sinus geometry and at the same time preventing coronary artery kinking.
- The results showed very good aortic valve competence after an ASO, and only 1.2% of the patients had postoperative moderate aortic valve regurgitation.
- Most of the patients (81%), when discharged after the operation, did not have any valve regurgitation, and only 17% showed mild regurgitation.
- Progression of aortic valve regurgitation to a clinically significant grade (moderate or severe) occurs rarely in the first 10 to 15 years after an ASO, giving a freedom from significant aortic regurgitation (>moderate) of 97% and 94%, respectively, for these time points.
- Although aortic functional status seems to be relatively stable in the first 15 years, a greater deterioration of valve competence occurs between 15 and 20 years of follow-up (, and freedom from regurgitation that is more than moderate decreases from 94% to 80% at 20 years

4D FLOW after ASO



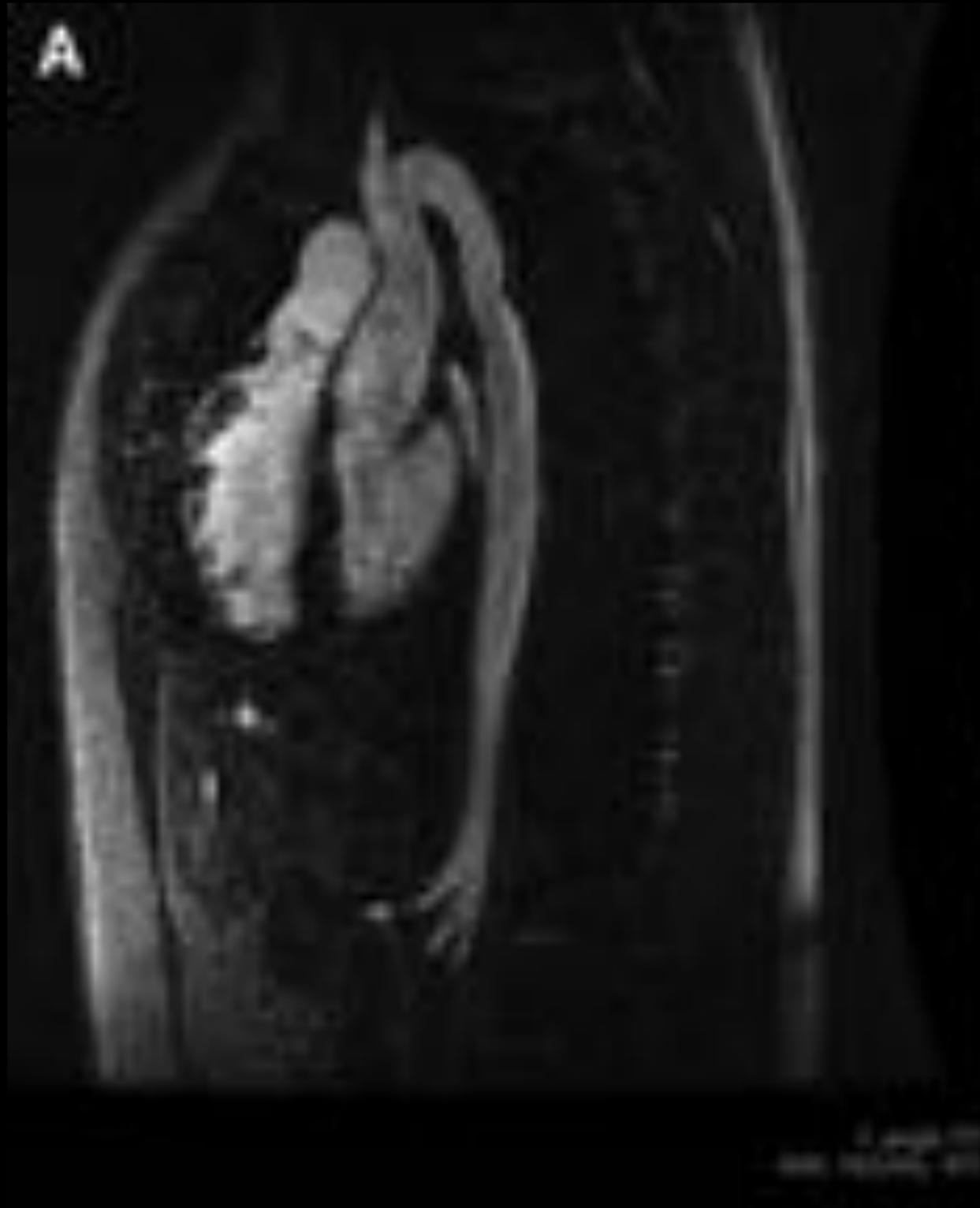


Aortic root and PA

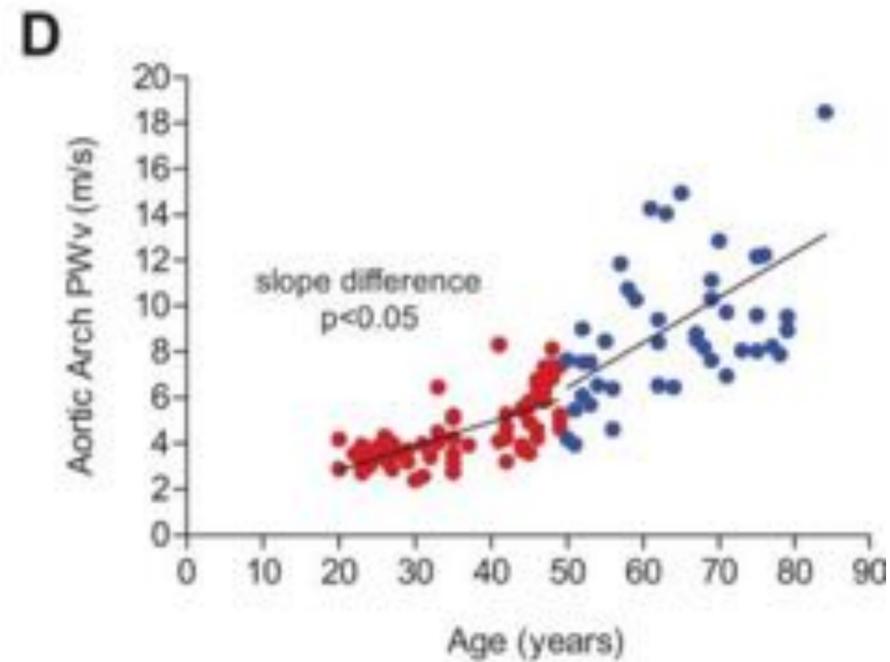
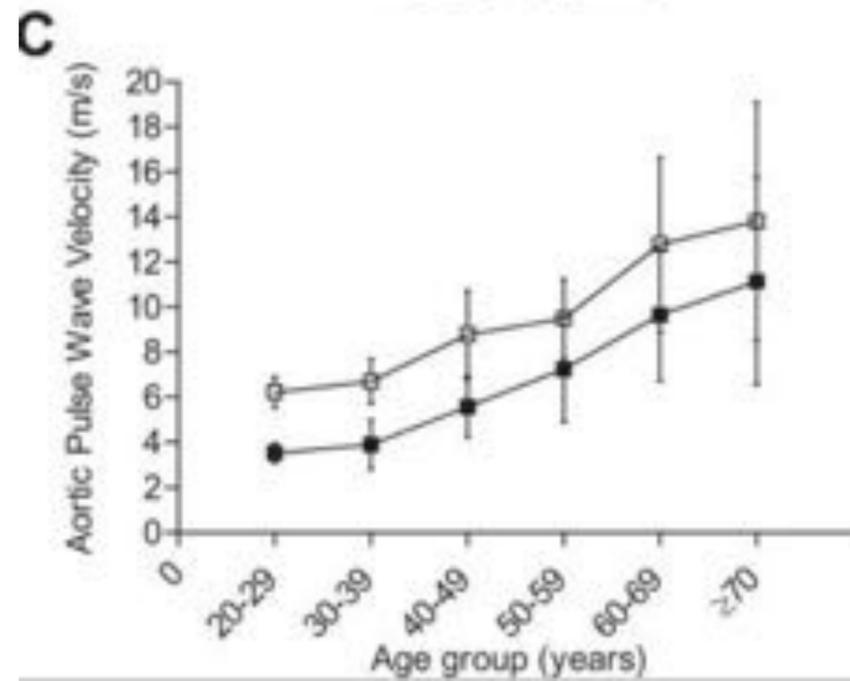
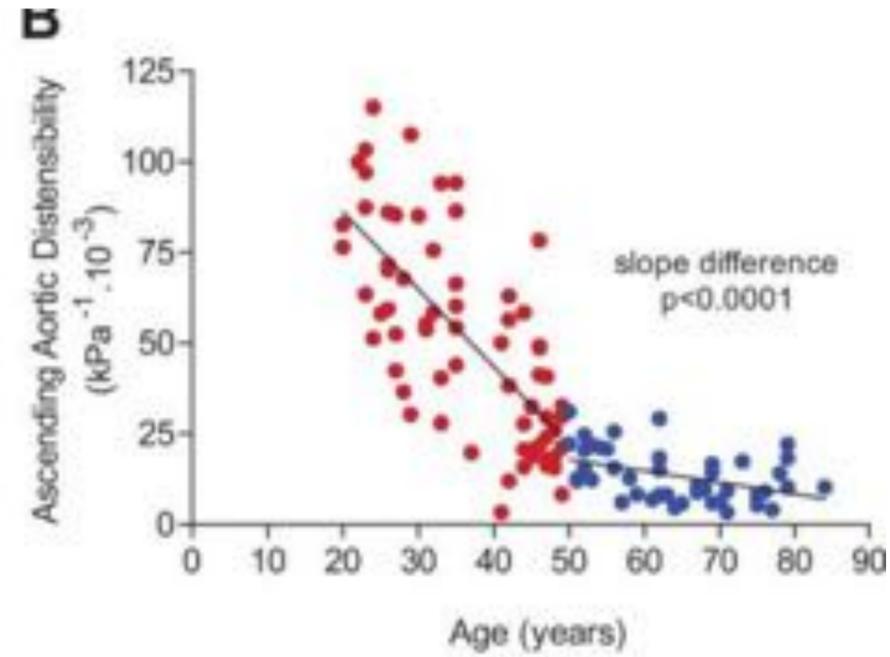
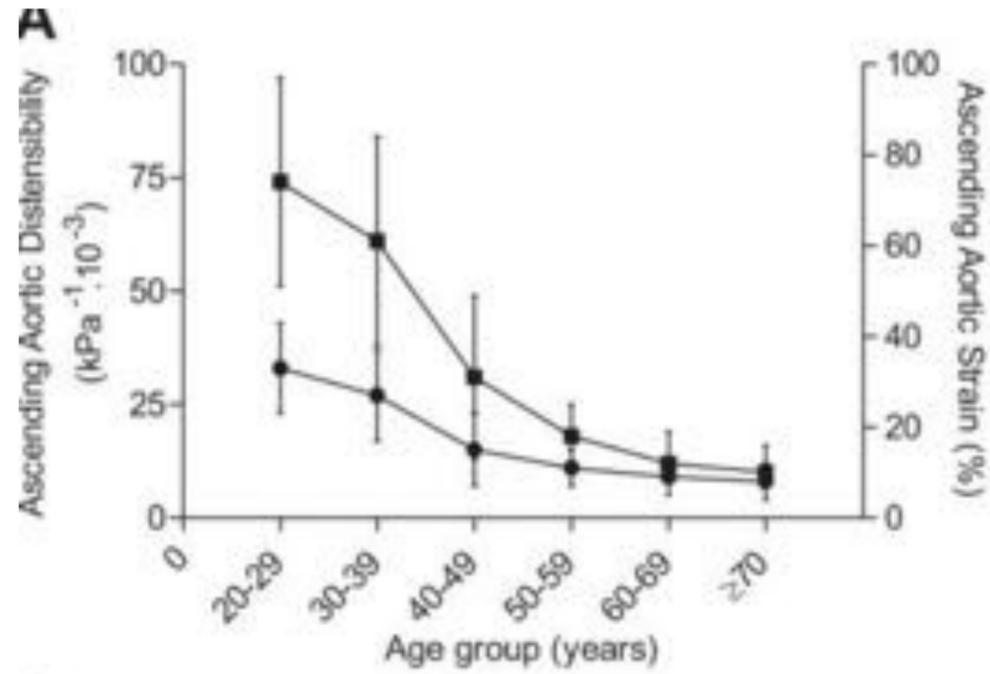


**Aortic root and
coronary
arteries**

Aortic arch angulation and systemic hypertension



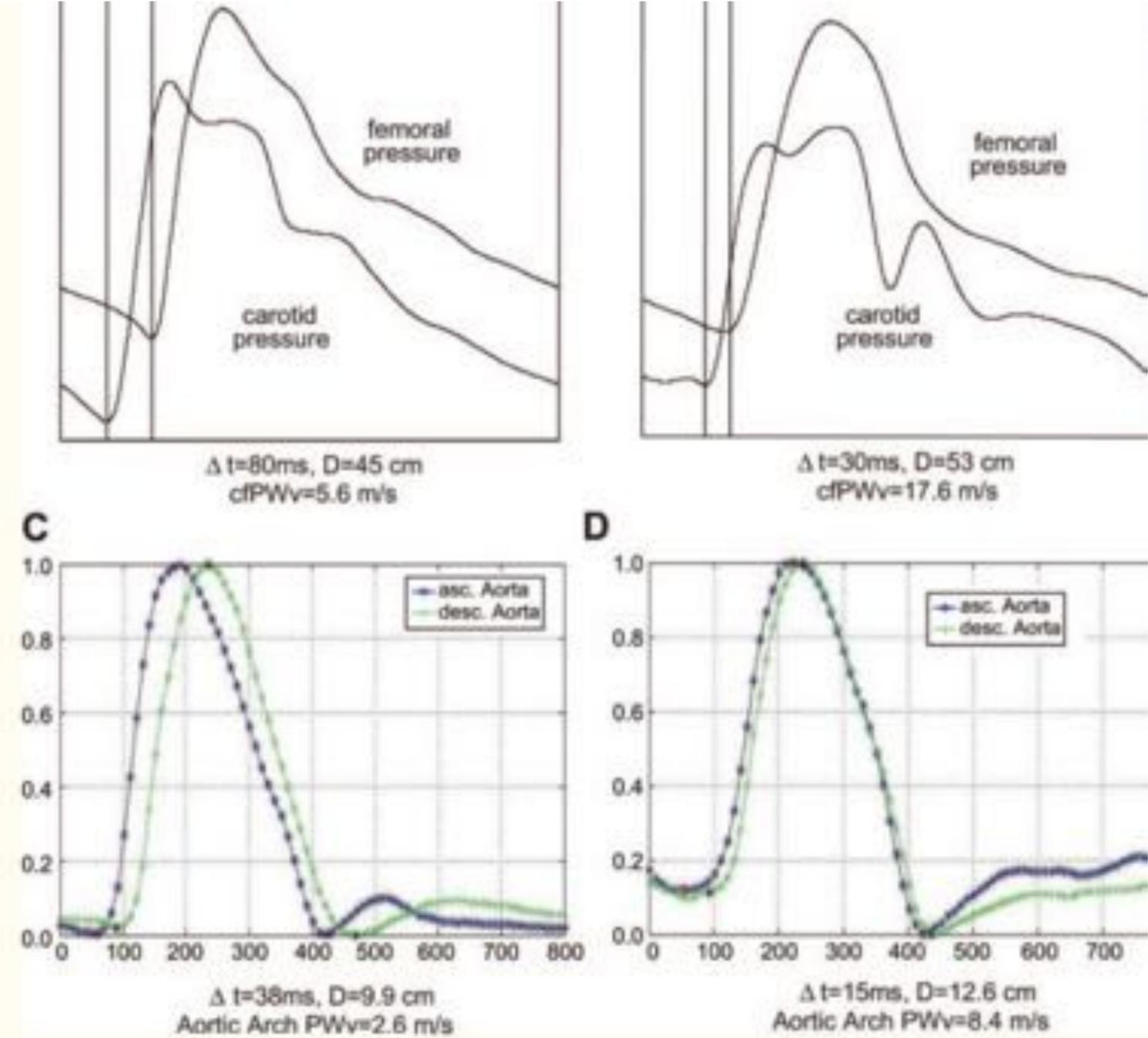
Aging aorta



Aortic properties

$$\text{Distensibility} = \frac{\Delta A}{A_{\text{min}} \times \text{cPP}}$$

$$\text{Aortic PWV} = \frac{D}{\Delta t}$$



At the moment : minor clinical problem

- Patients who have a competent valve immediately after the ASO are very unlikely (3.4%) to develop any late regurgitation
- For the future
- look more precisely at the entire aorta
- look for standard vascular risk factors
- look at the environment (PA and RV to PA prosthesis)