Aortic and carotid stiffening in patients after successful coarctation repair and its impact on left ventricular diastolic function

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I have nothing to disclose.

Background

- Despite successful repair, patients with aortic coarction (CoA) have a higher cardiovascular morbidity and mortality compared to the healthy population.

  (Pedersen et al. Congenit Heart Dis 2011, Cohen et al Circulation 1989)

- The main reasons therefore are systemic hypertension and accelerated arteriosclerosis which may affect left ventricular (LV) function in the long-term.

- However, the impact of aortic stiffness on systolic and diastolic LV function in young CoA patients is less well defined.

Aim

I. To evaluate the regional bioelastic properties of the thoracic aorta and their influence on LV systolic and diastolic function in patients after CoA repair using magnetic resonance imaging (MRI).

II. To assess bioelastic function and structure of the common carotid artery with MRI.

Methods
- Patients -

Parameter	CoA (n= 52)	Controls (n= 54)	P value*
Age (years)	18.9 ± 10.7	19.0 ± 7.9	0.54
Weight (kg)	61.7 ±26.4	58.0 ± 21.3	0.39
Height (cm)	163.8 ± 24.0	165.5 ± 20.9	0.99
BSA (m^2)	1.7 ± 0.5	1.6 ± 0.5	0.13
Blood pressure (mmHg)			
- Systolic	112.2 ± 15.4	107.0 ± 8.7	0.03
- Diastolic	60.8 ± 9.2	61.6 ± 10.5	0.7
Pulse pressure (mmHg)	51.7 ± 14.3	45.3 ± 9.0	0.03
Heart rate (bpm)	74.1 ± 15.7	70.3 ± 16.9	0.13

*Mann-Whitney-U Test

Methods
- MRI techniques -

- **3.0 T MR scanner** (Philips, Achieva)

- **Cross-sectional areas and distensibility**
  - **Axial gradient-echo cine sequences:**
    (voxel size 1.88 x 1.94 x 6 mm, TR/TE=4.4/2.5 ms, 25 cardiac phases)

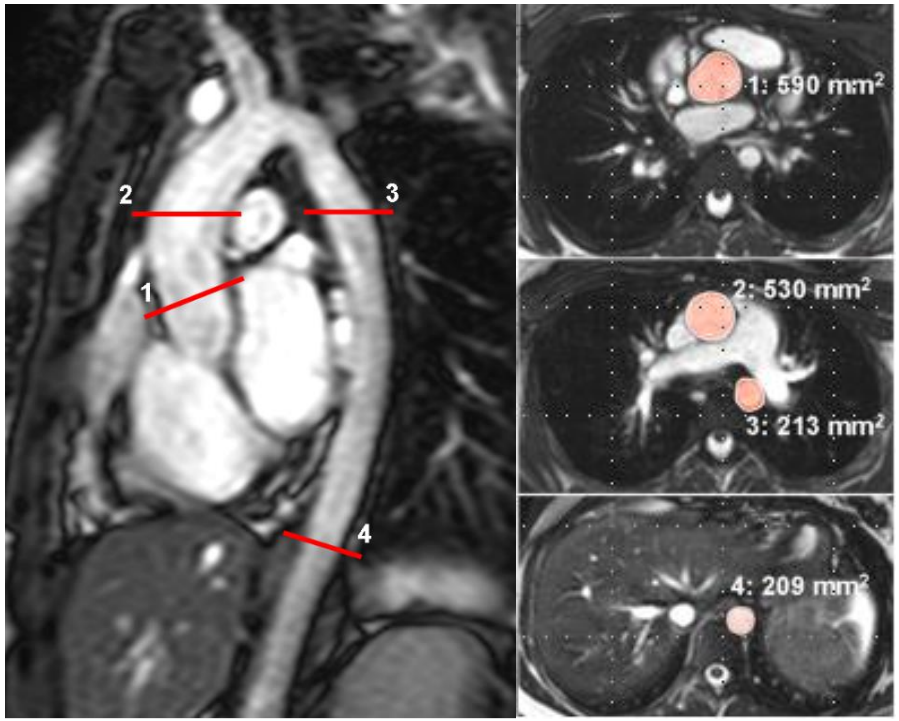
- **Pulse wave velocity (PWV)**
  - **2D phase-contrast cine sequences:**
    (FOV: 270 x 270 mm, voxel size 1.64 x 1.4 x 7 mm, TR/TE= 4.4/2.7 ms)

Methods
- MRI techniques -

- **Left atrial (LA) volumes**
  - **Axial gradient-echo cine sequences:**
    (voxel size 1.88 x 1.94 x 6 mm, TR/TE=4.4/2.5 ms, 25 cardiac phases)
- **LV volumes and systolic function**
  - **Short axis cine sequence:**
    (FOV 330 x 330 mm, voxel size 1.88 x 1.74 x 6 mm, TR/TE= 3.7/1.8 ms, 25 cardiac phases)
- **Carotid artery wall thickness and wall area**
  - **Multislice T2 dark blood fast spinecho sequence:**
    (FOV 160 mm, TR/TE= 3000/80 ms, slice thickness 2 mm, voxel size 0.2 mm, matrix size 251/384)

Aortic distensibility

Cross-sectional areas



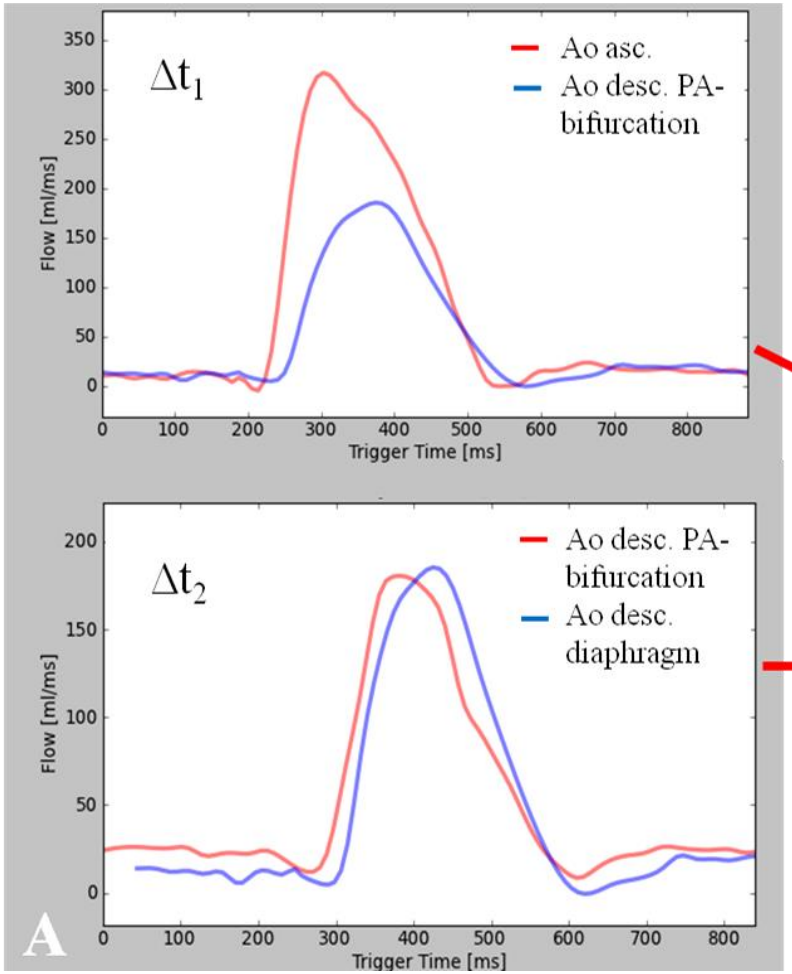
Non-invasive blood pressure measurement

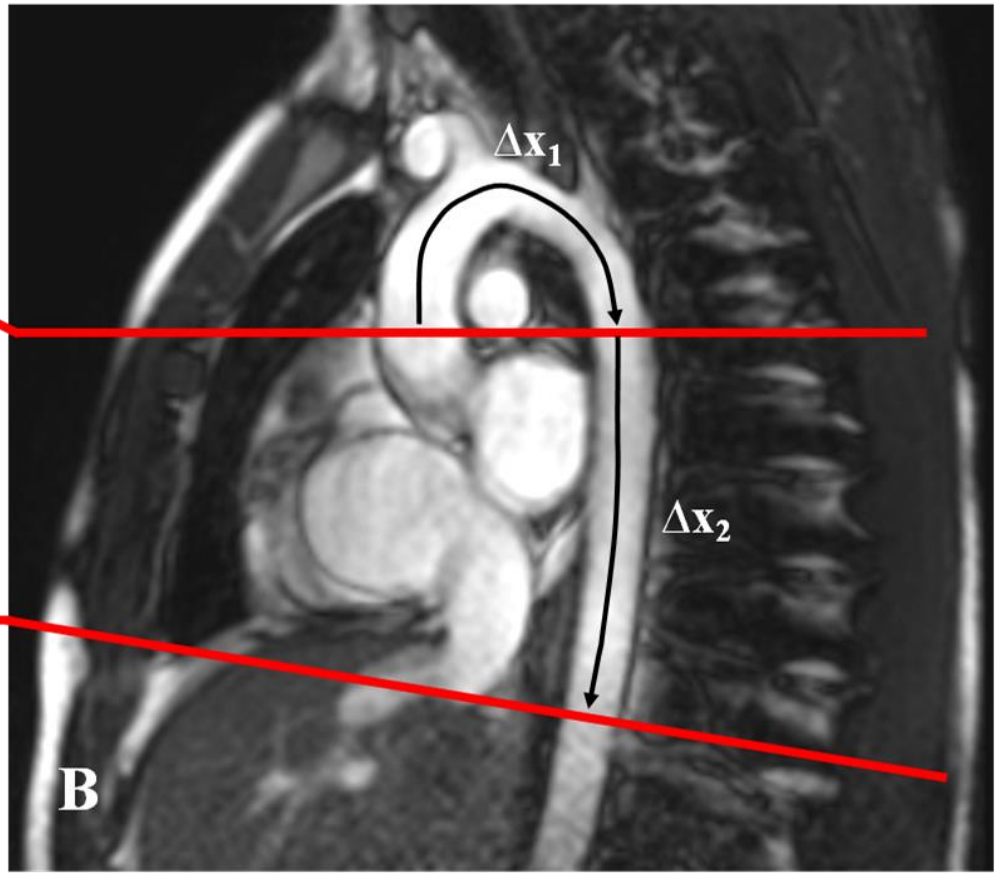
+

Distensibility = (Amax – Amin)/(Amin x (Pmax – Pmin))

A= Area, P= Blood pressure

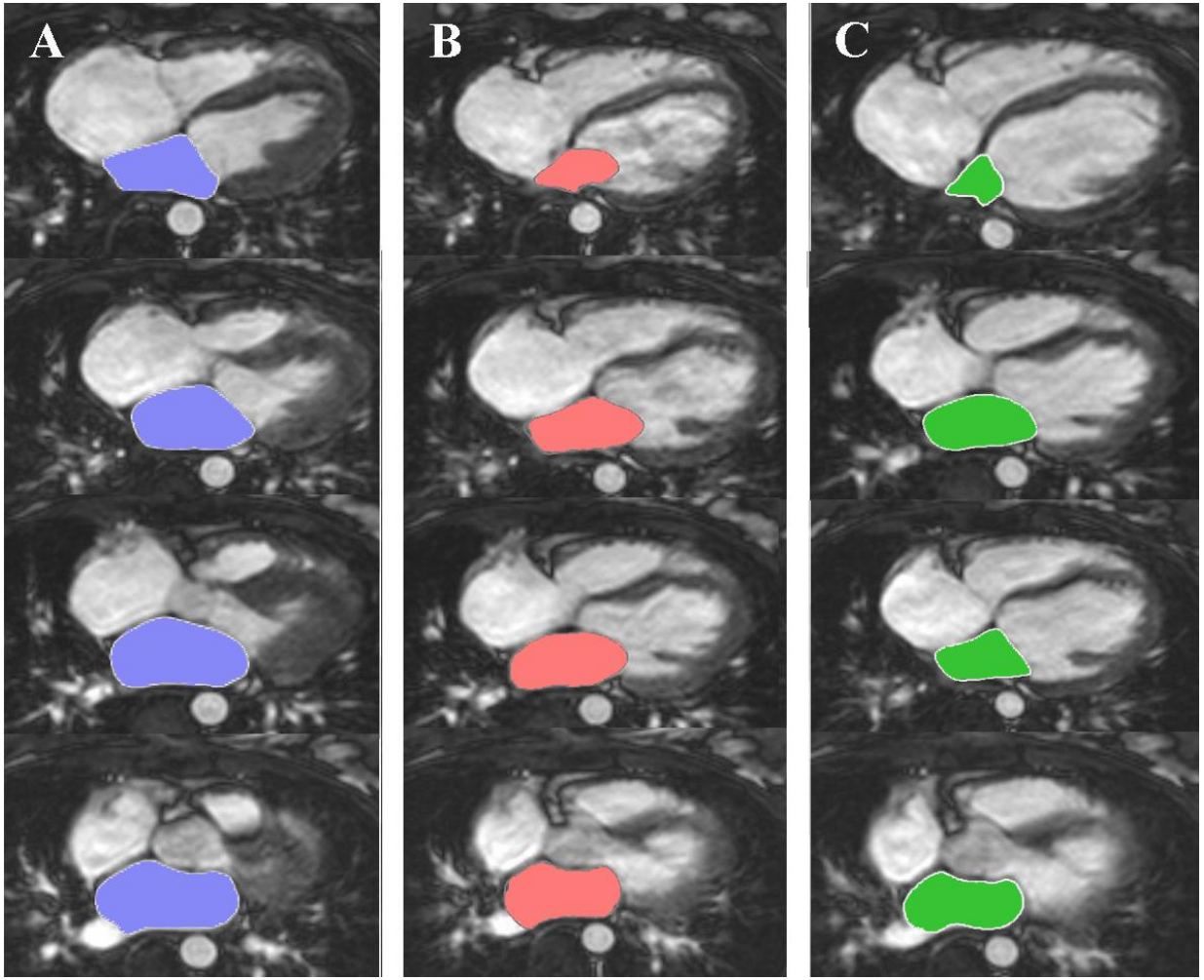
PWV


Δt1
Ao asc.
Ao desc. PA-bifurcation
Flow [ml/ms]
Trigger Time [ms]
Δt2
Ao desc. PA-bifurcation
Ao desc. diaphragm
Flow [ml/ms]
Trigger Time [ms]
A


Δx1
Δx2
B

PWV= Δx/Δt

LA volumes



Maximal LA volume ($LA\text{-}Vol_{max}$)

LA volume before atrial contraction ($LA\text{-}Vol_{ac}$)

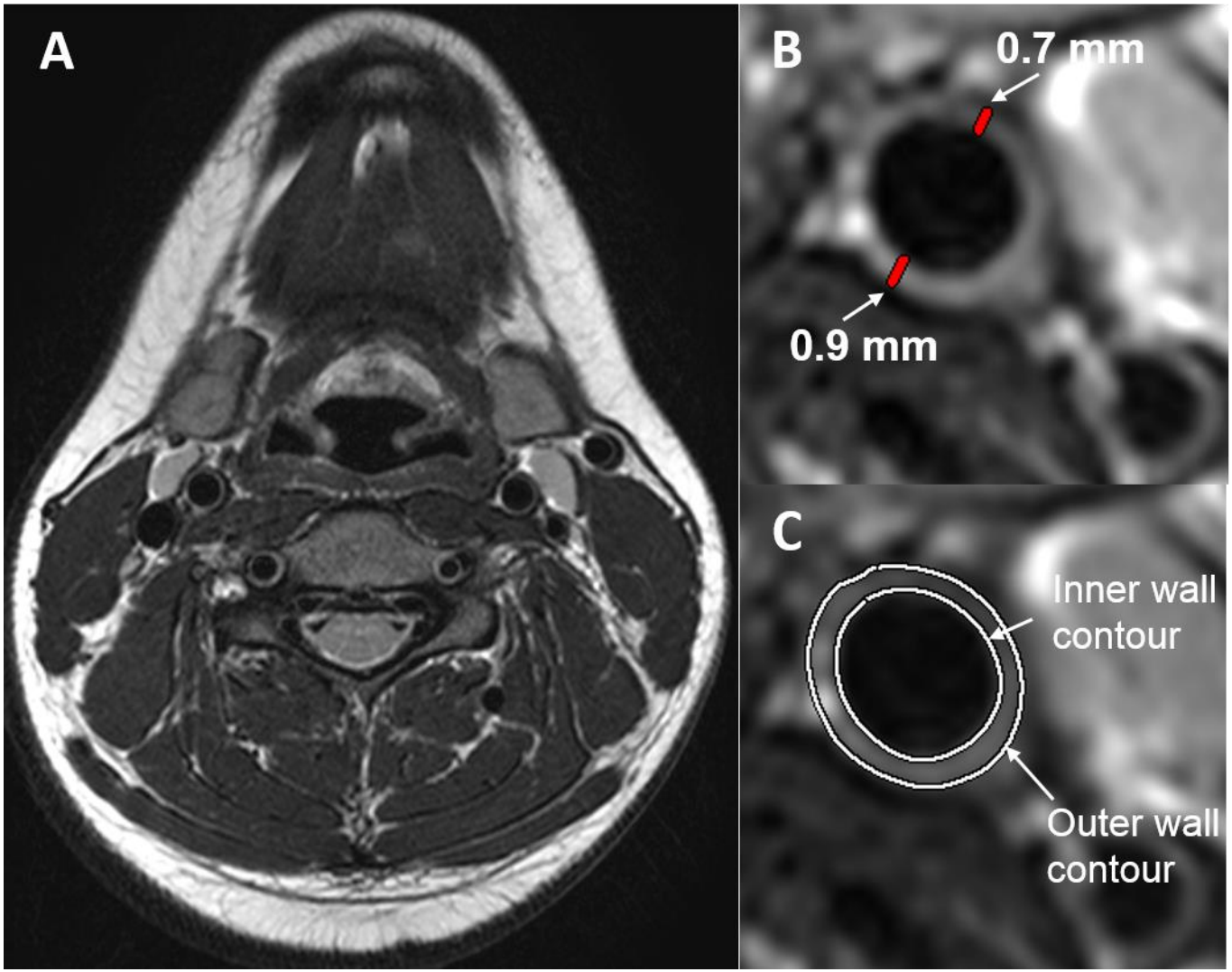
Minimal LA volume ($LA\text{-}Vol_{min}$)

LA functional parameters

- Passive emptying function ($LAEF_{Passive}$)= $(LA\text{-}Vol_{max} – LA\text{-}Vol_{ac})*100\%/ LA\text{-}Vol_{max}$
- Contractile emptying function ($LAEF_{Contractile}$)= $(LA\text{-}Vol_{ac} – LA\text{-}Vol_{min})*100\%/LA\text{-}Vol_{ac}$
- Reservoir emptying function ($LAEF_{Reservoir}$)= $(LA\text{-}Vol_{max} – LA\text{-}Vol_{min})*100\%/LA\text{-}Vol_{max}$

Kaminski et al., J Cardiovasc Magn Reson 2011
Farzaneh-Far et al., JACC Cardiovasc Imaging 2011

Carotid artery wall thickness and wall area



Mani et al.,
J Cardiovasc Magn Reson. 2006;

Harloff et al.,
Eur Radiol. 2009

Results
- Aortic Distensibility and PWV -

Variable	CoA (n= 52)	Controls (n= 54)	P value*
Distensibility (10^{-3} mm Hg^{-1})			
– Aortic root	5.5 ± 3.8	7.4 ± 3.0	<0.01
– Asc. aorta	5.8 ± 3.1	8.1 ± 3.6	<0.01
– Desc. aorta – pulmonary bifurcation	5.6 ± 3.0	6.8 ± 2.3	<0.01
– Desc. aorta – diaphragm	6.7 ± 2.8	8.0 ± 2.8	<0.05
PWV aortic arch (m/s)	4.7 ± 1.9	3.5 ± 0.8	<0.01
PWV descending aorta (m/s)	4.4 ± 1.7	3.8 ± 0.8	0.63

*Mann-Whitney-U Test

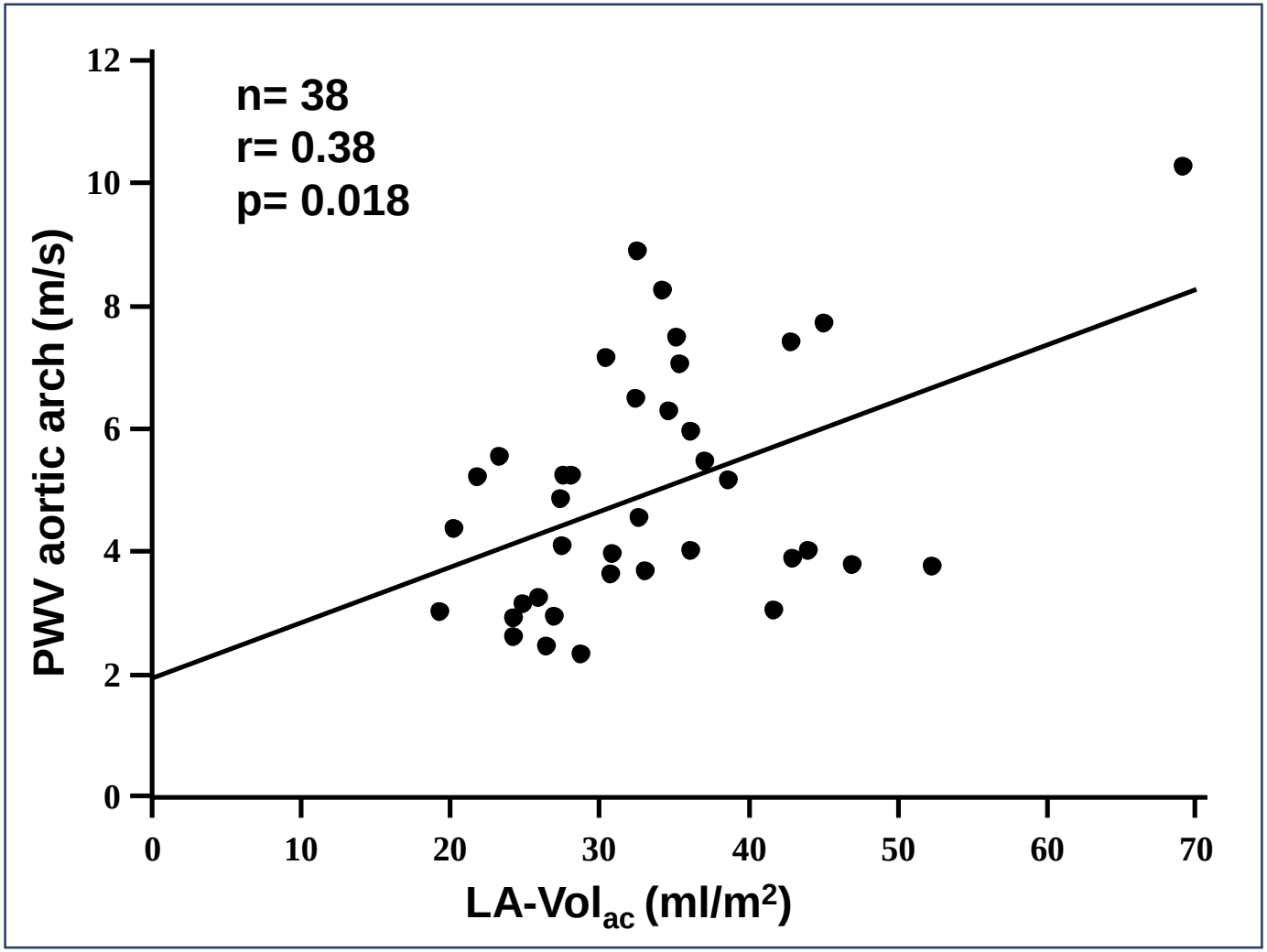
Results
- LA volumes and functional parameters -

Variable	CoA (n= 52)	Controls (n= 54)	P*
$LA\text{-}Vol_{max}$ (ml/m^2)	48.4 ± 11.4	43.2 ± 8.7	<0.05
$LA\text{-}Vol_{min}$ (ml/m^2)	25.3 ± 7.6	20.9 ± 5.1	<0.01
$LA\text{-}Vol_{ac}$ (ml/m^2)	33.2 ± 9.8	27.4 ± 5.9	<0.01
$LAEF_{Passive}$ (%)	31.7 ± 8.4	36.9 ± 6.6	<0.01
$LAEF_{Reservoir}$ (%)	48.0 ± 7.2	51.9 ± 6.8	<0.01
$LAEF_{Contractile}$ (%)	23.7 ± 7.1	23.7 ± 8.1	0.085

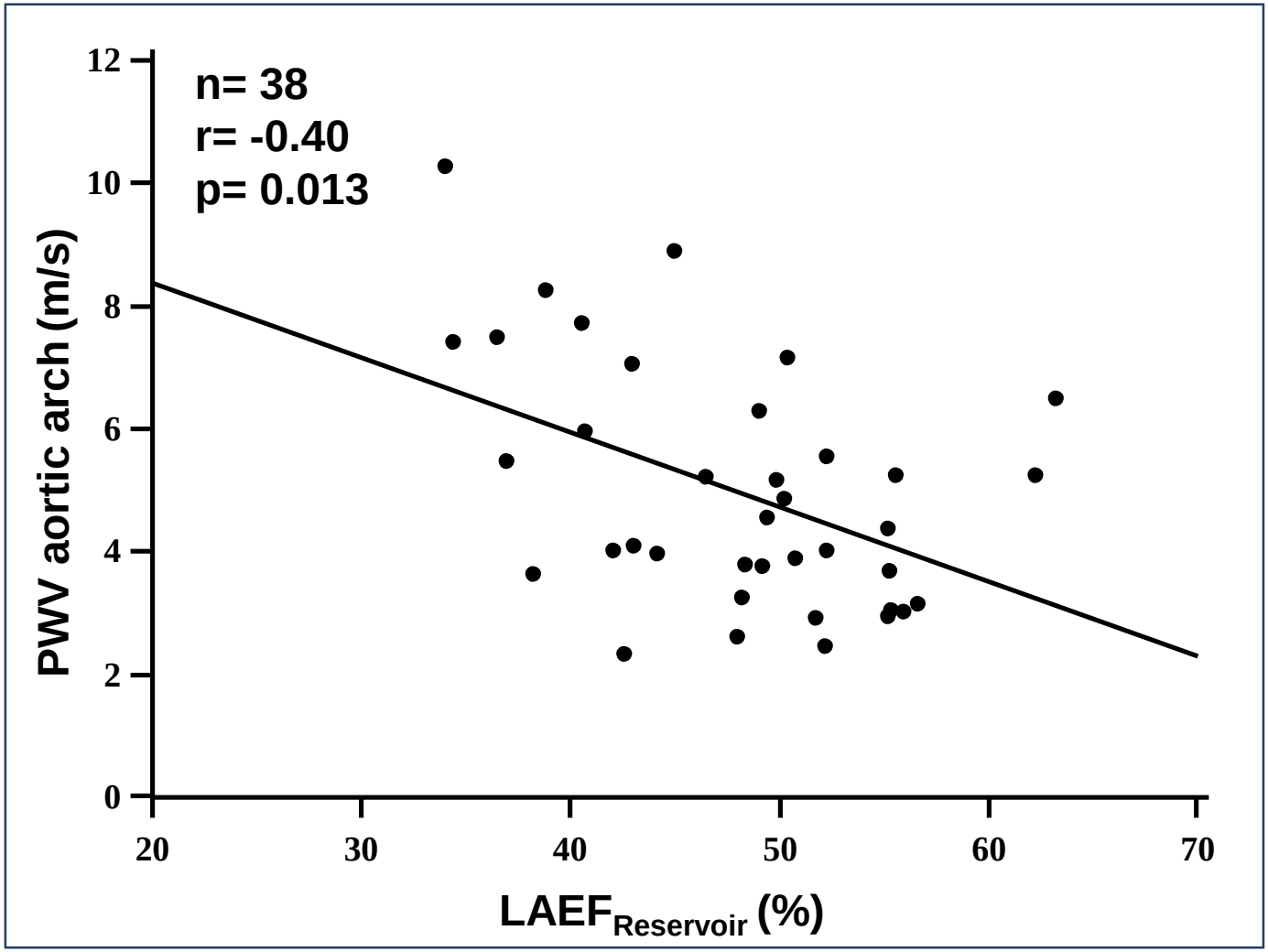
LV volumes, LVEF and LV mass were similar in patients and controls

*Mann-Whitney-U Test

LA-Vol$_{ac}$ vs. PWV



$LAEF_{Reservoir}$ vs. PWV



Carotid artery measurements

Variable	CoA (n= 11)	Controls (n= 13)	P*
PWV right (m/s)	6.9 ± 1.2	3.3 ± 1.5	<0.01
PWV left (m/s)	7.0 ± 3.8	4.2 ± 1.7	<0.01
Wall area right (mm^2)	22.1 ± 9.1	15.3 ± 2.6	<0.01
Wall area left (mm^2)	23.1 ± 12.1	15.8 ± 1.9	<0.01
Wall thickness right (mm)	0.94 ± 0.16	0.75 ± 0.09	<0.01
Wall thickness left (mm)	0.96 ± 0.19	0.76 ± 0.08	<0.01

Carotid distensibility were similar in patients and controls

*Mann-Whitney-U Test

Conclusions

- Patients after CoA repair have reduced bioelasticity of the entire thoracic aorta.
- The impaired aortic bioelastic function likely contributes to LV diastolic dysfunction.
- Beside an elevated aortic stiffness, we could show that CoA patients also have an increased carotid stiffness and abnormal carotid wall structure.

Thank you for your attention!