

Progressive contractile dysfunction after Norwood procedure compared to biventricular repair and isolated aortopulmonary shunt.

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Introduction

Ventricular dysfunction is an important contributor to morbidity and mortality early and late after the Norwood procedure. The perioperative course is associated with significant changes in ventricular load and risk of myocardial damage. However ventricular mechanics – especially the relationship between afterload and ventricular function – are not well understood.

Aim

Use MRI and advanced 3D modelling techniques to describe and contrast changes in ventricular geometry and mechanics before and after the Norwood procedure (NOR) with infants undergoing

- aortopulmonary shunt (APS)
- two ventricle repair (2VR)

Methods

A prospective longitudinal study with cardiac MRI.

- Pre** – prior to neonatal cardiac surgery
- Early** – median 7 days after surgery
- Later** – median 11 weeks after surgery

Patients

	NOR (9)	APS (7)	2VR (8)
Systemic RV	8	1	0
Age at Operation (days)	7 ± 4	6 ± 2	10 ± 6 (NS)
Interval Death	2	1	0

MRI

Cardiac MRI (1.5T) retrospective ECG-gated free breathing steady-state free precession, with 6 short axis, 3 long axis slices and 11.2msec temporal resolution. Sedation with chloryl hydrate as needed.

Analysis

3D interactively fitted guide-point modelling using customised software (CIM version 6.0, Auckland MRI Research Group) (Figure 1). Volume was calculated by numerical integration up to the ventricular base plane, and end-systolic radius and wall thickness measured in the short axis and averaged over 6 segments in the midventricular third of the ventricle (Figure 2).

Results

- Systemic ventricle ejection fraction (EF) in NOR was similar to 2VR and APS before operation but deteriorated progressively from before to late (p=0.003), and was lower than both groups at late follow-up (Figure 3A).
- Before operation end-systolic radius/thickness (r/T), an index of afterload, was elevated in NOR compared to 2VR and was similar to APS (Figure 3B). This pattern was unchanged early and late after operation. Blood pressure measurements were not different between groups.
- The EF vs. afterload relationship deteriorated in all groups immediately after operation. At later follow-up there was a further deterioration in the NOR group so that this index of contractile function was significantly lower in NOR than in the BVR and APS groups (Figure 4).

Figure 1. Interactive guide-point fitting (A) with an example of a 3D outer and inner shell model (B)

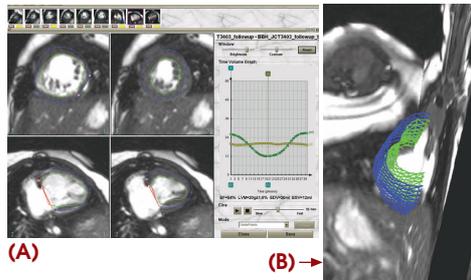


Figure 2. Radius (r) and thickness (T) measured in the short axis and averaged over 6 segments in the midventricular third of the ventricle.

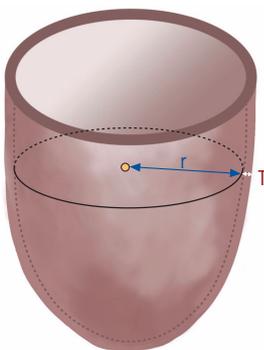
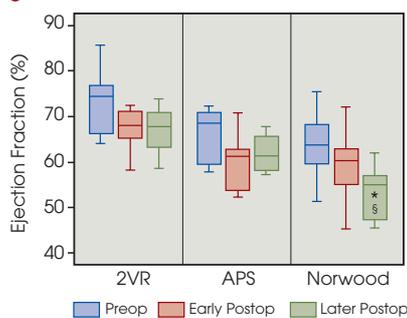
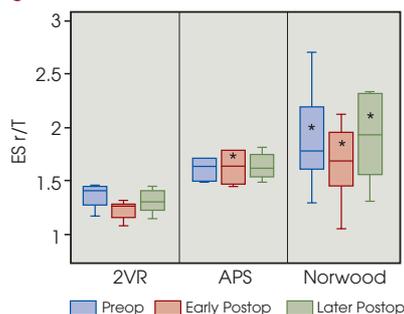


Figure 3A



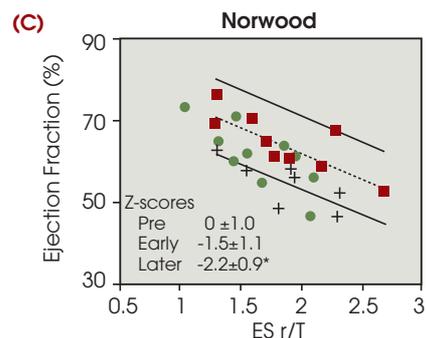
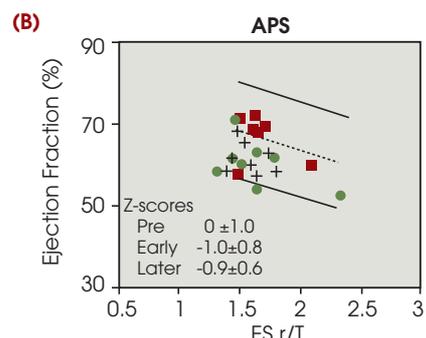
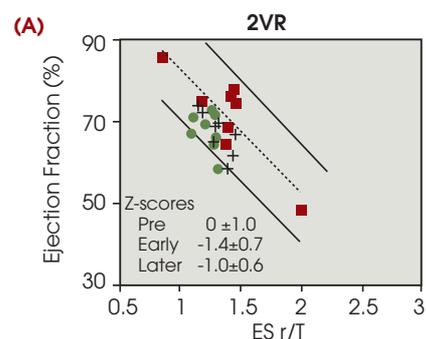
A progressive decline in ejection fraction (EF) in the Norwood group compared to 2VR and APS. (*p<0.05 compared to 2VR, §p<0.05 compared to APS).

Figure 3B



End systolic radius:thickness ratio (ES r/T) was elevated in Norwood and APS compared to 2VR (*p <0.05 compared to 2VR)

Figure 4. Ejection fraction (EF) vs. end-systolic radius: thickness ratio (ES r/T) for 2VR (A), APS (B) and NOR (C). Dotted and solid lines are mean ± 2SD from regression of the baseline (preoperative) relationship. Z-scores describe EF vs. r/T normalised for the baseline relationship. (*p <0.05 compared to BVR and APS)



Conclusion

After the Norwood operation a progressive deterioration in function occurs in the context of elevated, stable afterload. This finding, together with a decline in the EF-afterload relationship, is indicative of myocardial damage and has important implications for long-term prognosis.