MR Assessment of Left Ventricular Strain After Repair of Tetralogy of Fallot

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Introduction: Tetralogy of Fallot (TOF) is the most common type of the cyanotic congenital heart defect. Pulmonary regurgitation (PR) is the main hemodynamic sequela leading to right ventricular dilatation, dysfunction and increased risk of subsequent sudden cardiac death. A recent MRI study showed that severe enlargement of the right ventricle and decreased left ventricular ejection fraction (LVEF) are the strongest parameters independently predictive of cardiac events after repair of TOF (Knauth et al. Heart 2008). The mechanisms leading to LV dysfunction after correction of TOF are not completely understood.

Purpose: To determine the mechanisms leading to LV dysfunction in patients with pulmonary regurgitation after repair of TOF and to compare the data to normal volunteers. Cine and tagged MR imaging techniques were used for measuring global (LV volumes and LVEF) and regional (radial, circumferential strain and absolute LV rotation) LV function.

Methods: Twenty patients (mean age 32±13y; 7males) with repaired TOF and moderate to severe pulmonary regurgitation were prospectively recruited for this study. Additionally, 10 healthy volunteers (mean age 32±4y; 5males) were used as control reference. Cine MR images were acquired in the short axis plane for global ventricular function measurement and velocity-encoded cine MR for measurement of pulmonary regurgitant fraction. Tagging MR images were acquired in the short axis plane at the base, midventricular and apical levels for calculation of myocardial strain. For circumferential strain, endocardial and epicardial contours were delineated and the mid wall eularian circumferential strain (ECC%) was automatically calculated for the entire cardiac cycle from which the peak rotation, time to peak rotation, and circumferential strain were measured. Mean values were compared between patients and volunteers using the students' t-test for assessment of significance. Statistical significance was set at P-value <0.05.

Results: Pulmonary regurgitant fraction (PRF) varied from mild to severe (mean PRF = 34.5±16%). Right ventricular dysfunction was seen on cine MR imaging in 16 of the 20 patients studied, with a mean right ventricular ejection fraction of 43±9%. Patients presented mild to absent global LV dysfunction, with a mean LVEF of 57±7%. At the regional level, significant decrease in LV peak systolic circumferential strain was seen in patients with repaired TOF compared with normal volunteers (Table 1). The dysfunction was also seen throughout the cardiac cycle at basal, midventricular and apical slices. LV rotation was slower in patients compared with volunteers (Table 1 and Figure 1), resulting in a shorter diastole. Furthermore, pattern and degree of rotation in the septal and free LV wall differ in the basal slice of patients vs. volunteers. These changes were not associated with significant difference in R-R intervals between the groups (1042±30 ms in patients and 1072±33 ms volunteers).

Conclusions: MR myocardial tagging can quantify significant regional myocardial dysfunction in patients with TOF compared to controls. This study suggests that the most likely mechanisms of LV dysfunction in repaired tetralogy of Fallot patients are: 1) decline in systolic circumferential strain of LV and 2) delay in peak systolic rotation in the septum compared to lateral wall (dyssynchrony), and compared to volunteers.

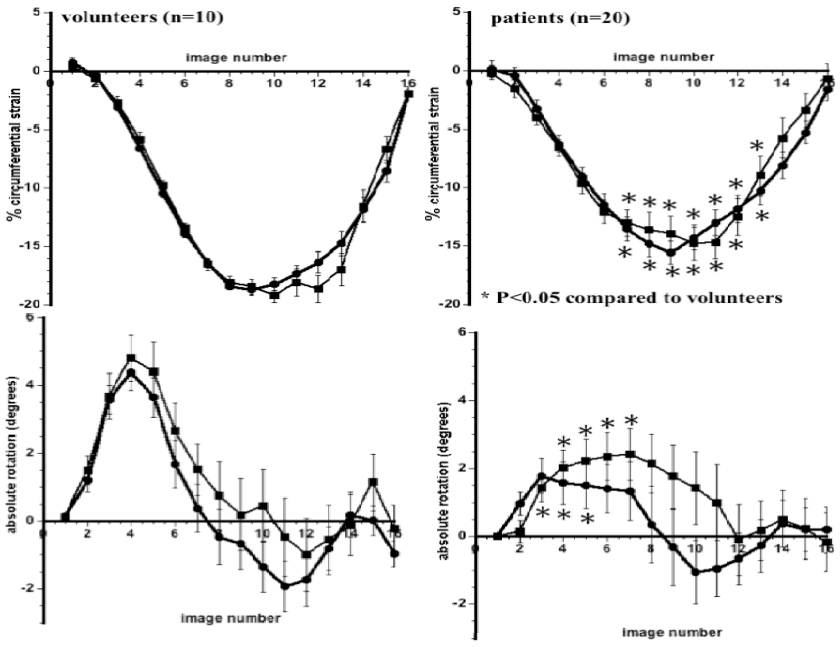

Table 1. Peak systolic circumferential Strain and absolute rotation in volunteers (n=10) and Tetralogy of Fallot patients (n=20), *P<0.05.

	Volunteers	Patients
Circ strain (%)		
Base	-17.3 ± 0.6	-143.6 ± 0.8*
Mid	-18.2 ± 0.9	-14.2 ± 0.7*
Apex	-18.5± 0.7	-11.9 ± 0.7*
Time to peak (ms)		
Base	561 ±69	600 ±27
Mid	563 ± 68	595±23
Apex	584 ±79	627 ± 27
Time to peak systolic rotation (ms)		
Base	274 ± 16	469 ± 71*
Mid	326± 27	582± 53*
Apex	491 ±34	534± 46*

Figure 1. Left ventricular septal (circles) and free wall (squares) circumferential strain (top) and absolute rotation (bottom) of basal slice in healthy volunteers (left) and Tetralogy of Fallot patients (right). Circumferential strain was impaired in patients compared with the volunteers. Note the difference in the pattern and degree of absolute rotation of the basal slice in patients compared with healthy volunteers.