

Magnetic Resonance Imaging Measurements Predict Need for Intervention in Patients Post Ross Procedure

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Introduction

The Ross procedure is an aortic valve replacement surgery performed to manage progressive disease of the aortic valve or left ventricular outflow tract. The operation entails the replacement of the aortic valve with a pulmonary autograft and reconstruction of the right ventricular outflow tract with a pulmonary homograft conduit (1). Complications of the Ross procedure include dilatation of the aortic root and aortic regurgitation, as well as pulmonary stenosis and pulmonary regurgitation (Figure 1) (2). These complications lead to cardiac surgery or minimally invasive interventions in many patients post Ross procedure. Magnetic Resonance Imaging (MRI) is increasingly utilized to non-invasively assess the left heart, right heart and pulmonary circulation in a variety of clinical scenarios including in patients post Ross procedure. In a previous study at our institute, it was found that patients post Ross procedure had prolonged pulmonary transit time compared to normal control patients. Pulmonary transit time and other pulmonary circulation parameters best correlate with worsened right ventricular ejection fraction and may be predictors of right ventricular dysfunction in this group of patients. The purpose of this retrospective study was to evaluate whether left heart function, right heart function and pulmonary circulation parameters as measured by MRI can predict need for intervention in patients post Ross procedure.

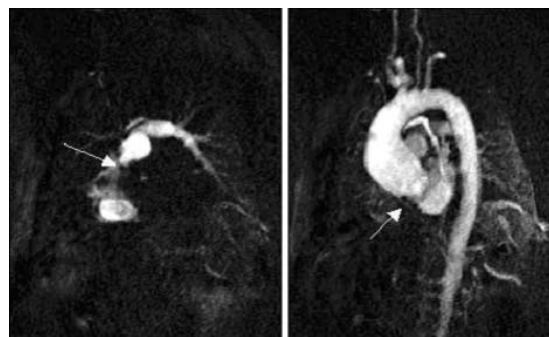


Figure 1. Select dynamic time-resolved CE-MRA images depicting pulmonary valve stenosis (left, arrow) and aortic valve dilatation (right, arrow) in a patient post Ross procedure.

Materials and Methods

Institutional review board approval was obtained.

Patient Population Sixteen patients post-Ross procedure with Cardiac MRIs between 2003 to 2007 were retrospectively selected and evaluated. Chart reviews on all patients were done. Outcomes included future need of cardiac surgery or minimally invasive interventions such as valvular percutaneous transluminal angioplasty or stent insertion.

Imaging Technique Imaging was performed using a Siemens 1.5T Avanto (Malvern, PA) with a 12-channel body array coil. The imaging protocol included multiplanar cine TrueFISP, phase contrast MRI (PC-MRI), dynamic time-resolved MR angiography (TR-MRA) and delayed enhanced imaging.

Quantitative Analysis All images were de-identified and transferred to a three dimensional post-processing workstation. Right ventricular (RV) and left ventricular (LV) volumetric parameters, including ejection fraction (EF), end systolic volume and end diastolic volume, were calculated from the cine TrueFISP images using the Argus post-processing software. Pulmonary valve velocity and flow were calculated from the PC-MRI images using the Argus post-processing software. Pulmonary transit time (TT) and time-intensity curves of pulmonary artery and aorta with full width at half maximum calculations were measured from dynamic TR-MRA using the Mean Curve post-processing software. Pulmonary blood volume (PBV) was calculated by multiplying the average flow through the pulmonary valve from PC-MRI by the pulmonary TT from the TR-MRA.

Statistical Analysis The results were statistically analyzed with SPSS for Windows (version 14.0). Cardiac MRI measurements were used to calculate odds ratios (OR) and relative risk (RR) for outcomes. Fischer's Exact Test was performed. Statistical significance was indicated by a p-value of less than 0.05.

Results:

Sixteen post Ross procedure patients (12 male, 4 female, mean age 42.13 ± 14.24 , age range 21-68) were identified with Cardiac MRIs. Mean interval and range between the Ross procedure and MRI was 5.85 ± 2.25 y. At a future date, 56.25% (9/16) required cardiac surgery, 12.5% (2/16) required a minimally invasive intervention, and 6.25% (1/16) required both surgery and minimally invasive intervention. Most interventions were performed within 1 year of the respective MRI.

Cardiac MRI measurements, including low LVEF ($\leq 65\%$), low RVEF ($\leq 55\%$), prolonged pulmonary TT (≥ 10 ms), and low PBV (≤ 600 ml), were used to calculate OR and RR for outcomes, including need for cardiac surgery or any cardiac intervention (see Table 1). Neither low LVEF nor RVEF predicts surgery or any cardiac intervention. However, there is a trend for prolonged pulmonary TT to predict cardiac surgery (OR 8.0 [0.803-79.655]) and any cardiac intervention (OR 9.0 [0.660-122.794]). Likewise, there is a trend for low PBV volume to predict cardiac surgery (OR 6.25 [0.504 - 77.494]).

	Odds Ratio for Surgery	Relative Risk for Surgery	Fischer's Exact Test for Surgery (p-value)	Odds Ratio for Any Intervention	Relative Risk for Any Intervention	Fischer's Exact Test for Any Intervention (p-value)
LVEF ≤ 65	1.500 (0.195 - 11.536)	1.167 (0.529 - 2.572)	0.549	6.000 (0.463-77.750)	1.556 (0.787- 3.076)	0.192
RVEF ≤ 55	2.000 (0.244 - 16.362)	1.286 (0.608 - 2.719)	0.451	3.000 (0.239-37.672)	1.286 (0.740 - 2.233)	0.392
TT ≥ 10	8.000 (0.803 - 79.655)	2.400 (0.742 - 7.758)	0.092	9.000 (0.660-122.794)	1.800 (0.788 - 4.113)	0.118
PBV ≤ 600	6.250 (0.504 - 77.494)	1.875 (0.831 - 4.229)	0.168	N/A	1.800 (1.003 - 3.229)	0.092

Conclusion:

In this retrospective study of Cardiac MRIs of patients post Ross procedure, we have determined that pulmonary circulation parameters best predict need for future intervention. Our results show trends; these results are non-significant most likely due to small numbers. Nonetheless, there is a trend for both prolonged pulmonary TT and low PBV to have high OR and RR for need of future cardiac surgery or any cardiac intervention.

MRI derived pulmonary circulation parameters might be useful for monitoring or predicting the progression of cardiac disease in Ross Procedure patients. Further physiological understanding of pulmonary circulation parameters is essential and more studies are needed to delineate their use in the clinical setting.

Literature Cited:

1. Moss & Adams' Heart Disease in Infants, Children & Adolescents: Including the Fetus and Young Adults, 2001.
2. Marino BS, Pasquali S, Spray TL, Wernovsky G. Is the Ross procedure as good as we thought it would be? *Cardiol Young* 2006; 16 Suppl 3:125-130.