Evaluation of regurgitation and turbulence of in-plane flow in branch pulmonary arteries after repair of tetralogy of Fallot by means of phase-contrast MR imaging.

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Introduction

Pulmonary regurgitation has been regarded as an important feature for long-term clinical outcome after repair of tetralogy of Fallot (TOF). The interest of applying phase-contrast cine magnetic resonance (PCMR) as an accurate method for evaluating flow velocity, volume and pattern has also been increasing [1]. Besides, the pattern of turbulence flow due to regurgitation potentially provides more detailed information than quantitative regurgitation fraction. Our preliminary result [2] shows the correlation between regurgitation fraction and coefficient of variation (CV) of in-plane flow speed. In this work, we further investigated the correlation among variation of cross-sectional area, CV of in-plane flow speed and regurgitation fraction in the branch pulmonary arteries in patients of TOF.

Materials and Methods

A total of twenty-nine patients (age: 4.91±3.38 y/o, 9 female and 20 male) with after repair of tetralogy of Fallot (TOF) were included in this study. All patients underwent MR studies performed on a 1.5T system (General Electric, Milwaukee, WI). Phase-contrast (PC) MR imaging of main pulmonary artery (MPA), right (RPA) and left (LPA) pulmonary arteries was acquired by double-oblique method to obtain true perpendicular plane of long axis of the pulmonary artery with retrospective ECG gating. Flow velocity of twenty different time phases was measured in three dimensions throughout the cardiac cycle with upper velocity limit (Venc) set at 200 cm/sec. Region of interest (ROI) was manually defined from anatomic MR images of thorax accordingly. Quantitative flow analysis was achieved by the built-in software of commercially workstation (GE Medical System) as well as in-house software. Regurgitation fraction was calculated from division of backward flow by forward flow. The coefficient of variation (CV) of in-plane flow speed within the ROI for each time phase was calculated according to the definition [3]: *CV=[(standard deviation of speed)/(mean of speed)]×100%*. The average of CV from the total 20 phase (CV-mean) was afterwards taken into account for the turbulent flow pattern. Cross-sectional area of the arteries was calculated according to the manually defined ROI. The variance of the ROI area among 20 time phases was evaluated by maximum and mean area of ROI, i.e., *[(Area_max – Area_mean)/Area_mean]×100%*. We used SPSS software package for statistical analysis.

Results and Discussion

Values of net flow, regurgitant fraction, CV-mean as well as area variation for RPA and LPA were listed in Table 1. Significant difference has been shown between LPA and RPA by net flow, regurgitant fraction and CV-mean. Figure 1 and 2 show the correlation of cross-sectional area variation with CV-mean and regurgitant fraction respectively. There is a linear relationship between CV-mean and the area variation in the LPA (R^2=0.2705, p=0.0037), yet the linearity reveals weak in the RPA (R^2=0.1709, p=0.28).

Our result demonstrates the regurgitant fraction is able to evaluate the flow behavior after repair of TOF, which is consistent with previous reports [1]. CV-mean as well as net flow can be useful indicators to quantify turbulence flow. Cross-sectional area variation can represent the pulsation of arteries, which is influenced by the regurgitation and thus the turbulence of flow. The positive correlation between regurgitation fraction and ROI area variation is consistent with the inference, yet the negative correlation between CV-mean and ROI area variation may provide valuable information of the hemodynamic behavior in branch pulmonary arteries after repair of TOF, and deserves further investigation for clinical applications.

Figure 1

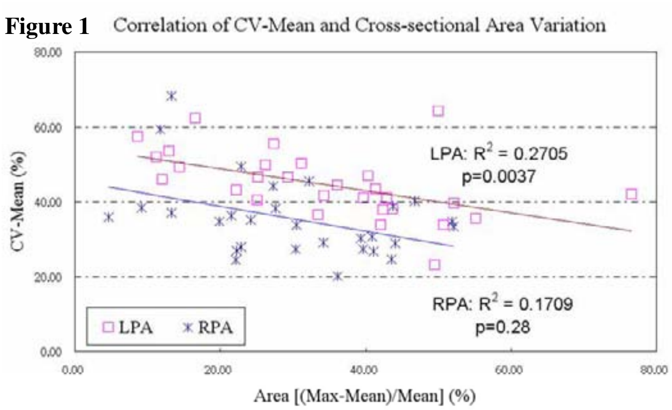

Figure 2

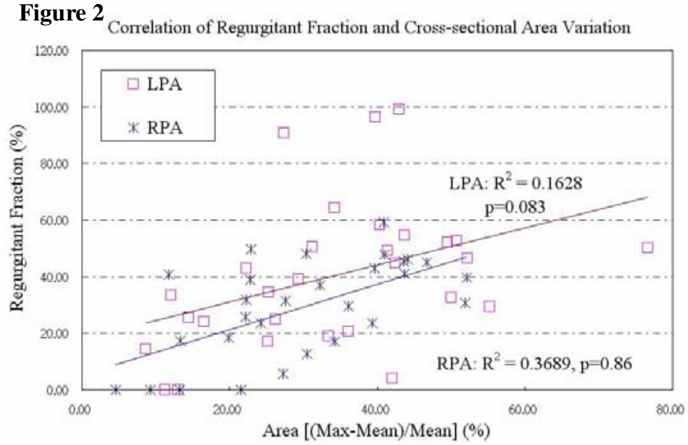

Table 1. Summary of the analyzed values for LPA and RPA.

	LPA (n=29)	RPA (n=29)	T-test (p value)
Net Flow (ml/min)	683.98±587.42	1382.26±771.59	**0.0001**
Regurgitant Fraction (%)	40.39±25.68	29.28±17.17	**0.0119**
CV-Mean (%)	44.62±8.92	35.44±10.41	**0.0002**
Area Variation (%)	34.27±15.83	29.97±12.98	0.1405

Figure 1. Linear correlation analysis of CV-mean and ROI area variation for LPA and RPA respectively. Negative correlation may be worth further studying for physiological meaning.

Figure 2. Linear correlation analysis of regurgitation fraction and ROI area variation for LPA and RPA respectively. Positive correlation agrees our inference though the correlation coefficient is significant enough.

References

1. Kang et al., Circulation, 2003; 107:2938.
2. Niu et al., ISMRM, 2006.
3. Be'eri et al., Circulation, 1998; 98:2873.