Influence of pulmonary regurgitation inequality on differential perfusion of the lungs in tetralogy of Fallot post-repair: a phase-contrast MRI and perfusion scintigraphy study

M-T. Wu[1], C-W. Ko[2], Y-R. Lin[3], Y-L. Huang[4], and K-S. Hsieh[5]

[1]Radiology, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, Taiwan, [2]Computer Science and Engineering, National Sun Yat-sen University, Kaohsiung, Taiwan, [3]Electronic Engineering, National Taiwan University of Science and Technology, Taiwan, [4]Radiology, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, [5]Pediatrics, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan

Introduction

Phase-contrast MRI (PC-MRI) has been validated as a simple and accurate method to evaluate the severity of pulmonary regurgitation (PR) in Tetralogy of Fallot (TOF) post-repair. Although the impact of PR on right ventricular dysfunction has been extensively investigated, its impact on lung perfusion has not been explored yet. Recently, it has been found that in repaired TOF, the branch pulmonary arteries often has unequal regurgitation fraction (RF) and contribute unequally to total regurgitation. In the present study, we used PC-MRI, as compared to ^{99m}Tc-MAA perfusion scintigraphy (PS), to investigate the influence of RF inequality on differential lung perfusion in TOF post-repair.

Materials and Methods

Forty-three TOF post-repair patients (median age=51 months, 31 males) received PC-MRI and ^{99m}Tc-MAA perfusion scintigraphy (PS) in the same day. We took PC-MRI measurements of forward flow volume (FFV), backward flow volume (BFV), and net flow volume (NFV, =FFV-BFV) and regurgitation fraction (RF, =BFV/FFV) at the left and right pulmonary arteries (LPA and RPA). The differential perfusion of the left lung (L%, =left lung/left+right lung) was calculated by three methods: (1) according to NFV ratio of PC-MRI, is defined as L% by NFV = NFV of LPA / (NFV of LPA + NFV of RPA) × 100%; (2). according to FFV ratio of PC-MRI and (3). according to PS ratio were compared.

Results

The discrepancy between L% by NFV vs. L% by PS was affected by the severity of RF of LPA (r=-0.51, P=0.001); agreement between L% by NFV vs. L% by PS was good (Ri=0.87) if RF of LPA <0.4 (N=23), but downgraded (Ri=0.51) and underestimated the L% (median of error=-14%, range=-25.3 to 5.5%) if RF of LPA≥0.4 (N=20). In contrast, agreement between L% by FFV vs. L% by PS was high and unaffected by RF of LPA (Ri=0.94, 0.92, respectively).

Discussion

PC-MRI at LPA and RPA provides the absolute volume of bulk flow input into the lungs. Conventionally, NFV, i.e. FFV minus BFV if any, is used to represent the total flow volume passing through the interrogated vessel. On the other hand, PS employs ^{99m}Tc-labeled macroaggregates of albumin embolized at capillary level to represent the relative tissue perfusion ratio of the lung. To predict the differential lung perfusion using PC-MRI, previous reports calculated the NFV ratio of LPA and RPA and found good agreement with that by PS ratio in the scenario of most congenital heart diseases. Our result showed that in TOF post-repair in which severe RF often occurs, FFV ratio, instead of conventional NFV ratio, of LPA and RPA should be used to predict the differential lung perfusion.

Our study showed a method to improve the accuracy of PC-MRI in assessment of the differential lung perfusion and therefore could substitute PS in postoperative evaluation of TOF. The clinical impacts include (1) avoiding isotope radiation of PS; (2) increasing cost-effectiveness of MRI and (3) providing absolute quantitation of flow volume, not only relative perfusion ratio. All the three impacts are further enhanced in long-term follow up of TOF post-repair.

Table Agreement between differential lung perfusion estimated by perfusion scintigraphy vs. MR flow measurements

		L% by NFV vs L% by PS		L% by FFV vs L% by PS	
RF of LPA	N	*Ri*	*95% CI*	*Ri*	*95% CI*
All	43	0.70	(0.51, 0.82)	0.94	(0.88, 0.96)
< 0.4	23	0.87	(0.71, 0.94)	0.94	(0.88, 0.98)
≥ 0.4	20	0.51	(0.12, 0.77)	0.92	(0.82, 0.97)

Ref.

Kang IS. Circulation 2003; 107:2938; **2.** Frigiola A. Circulation 2004; 110:II153; **3**. Sridharan S, Heart 2006; 92:963; **4.** Roman KS, Pediatr Radiol 2005; 35:295

Fig 1. Scatterplot of regurgitation fraction of left pulmonary artery vs. discrepancy between differential perfusion of left lung (L%) calculated by MRI flow and perfusion scintigraphy (PS). NFV, net flow volume; FFV, forward flow volume.

Fig. 2 Bland-Altman plots of differential perfusion of the left lung (L%) measured by MRI flow vs. perfusion scintigraphy (PS). NFV, net flow volume; FFV, forward flow volume. SD, standard deviation.

Figure 1.

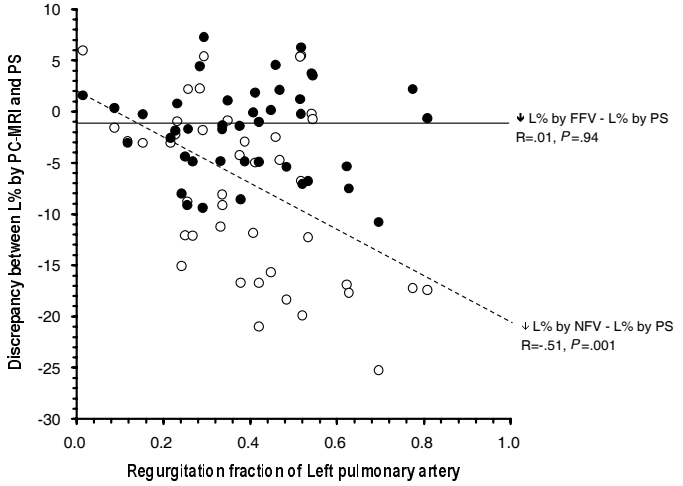

Figure 2.