Background: Regurgitant flow fraction (RF) is an important parameter for monitoring valvular insufficiency. On the basis of regurgitant severity and the hemodynamic consequences on the right or left ventricle surgical management might be recommended. The standard method to quantify flow by magnetic resonance imaging is to average the flow across the lumen of a vessel for each heart phase [1]. Then, the averages of each heart phase are summed according to the flow direction to obtain forward and backward flow. Therefore, regurgitant flow is detected only if the average of flow velocities is negative in one or more cardiac phases. Nonetheless, there are situations in which there are both forward and backward flow across a vessel lumen in the same heart phase. As we have shown in patients with repaired TOF, regurgitant flow is detected only if the average of flow velocities is negative in one or more cardiac phases. Nonetheless, there are situations in which there are both forward and backward flow across a vessel lumen in the same heart phase. Since flow is being counted in each heart phase, backward flow might be missed in these situations and therefore underestimated (see Standard method in Fig. 1.). We propose to quantify flow by summing the individual flow components (voxel-based) for forward and backward flow in each heart phase. This method would provide a better estimation of regurgitation fraction when forward and backward flows are present in the same heart phase (see Voxel-based method in Fig. 1.).

Purpose: To determine whether RF is underestimated by the standard method compared to the voxel based-method.

Methods: RF was estimated in the pulmonary artery by both methods in 17 patients with repaired Tetralogy of Fallot (TOF). TOF is the most common cyanotic congenital heart disease. These patients were chosen to compare both methods since pulmonary insufficiency exists after surgical correction. A 2D phase-contrast sequence was acquired in the pulmonary artery of these patients on a 1.5 T MRI scan. The protocol was approved by the local ethic committee. Informed consent was obtained. Values of forward flow volume, backward flow volume, net forward flow volume and regurgitation fraction were quantified by using the standard method and the voxel-based method. All flow data analysis was carried out using the commercially available software QFlow (v. 2.0.4). Statistical analysis of the difference between both methods was performed using Bland-Altman plots and the non-parametric test for related samples Wilcoxon signed-rank test.

Results: Mean RF was 30 ± 22 % with the standard method vs. 41 ± 15% with the voxel-based method (p-value <0.01). Bland-Altman plot (Fig 2.) showed a systematic bias, with greater values of RF obtained by the voxel based-method (mean difference between both methods: 10.9 %; range: -1% to 38%). 6 patients had a mean difference of more than 10%. 2D flow profile from patients with greater values of RF by the voxel based-method revealed forward and backward flow simultaneously across the pulmonary artery during systole (Fig. 3).

Conclusion: Calculation RF using the average flow volume of each heart cycle might result in underestimation of RF, when both forward and backward flows are present in the same heart phase. As we have shown in patients with repaired TOF, calculating the RF by the standard method results in lower values of RF compared to the voxel based-method. Since surgical management might be recommended for TOF patients with high RF to avoid right ventricle failure, the standard method may not reflect the real hemodynamic and not detect patients who might benefit from surgical intervention.