Magnetic resonance 2D phase contrast flow imaging of patients with stenotic aortic and pulmonary valves

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Introduction: 2D trough plane phase contrast velocity imaging is a widely used method to measure pulmonary and aortic artery flow. When imaging patient with normal morphology the measurement plane is relatively small factor in the measurement error. However, in case of highly accelerated flow through the stenotic valve the results depend highly on the position of the measurement plane [1]. Error originating from the acceleration artefact is significant near the valve. Due to valve stenosis the turbulence increases as the flow recedes from the valve. In this study we have examined the effect of the measurement plane distance from the valve to the measured net flow. Also, currently used clinical routine in the flow measurements is presented.

Methods: The patients were imaged according to present clinical routine. First, in-plane phase encoded flow images were acquired along the left and right ventricular outflow tract. In-plane images were used to visually assess the speed and the direction of the flow, which may divert considerably from the tract direction in abnormal cases. Thereafter, through plane measurements were acquired along the flow with different distances from the valve. The measurement planes were set perpendicular to the in-plane flow image and the flow direction.

Imaging was performed with 1.5 T Siemens Avanto (Erlangen, Germany) scanner with 6 channel body coil. Flow images were acquired in breath hold with phase contrast fast gradient echo pulse sequence using GRAPPA-factor of two. The acquisition parameters in the through plane sequence were matrix = 128 x 256, TE = 3.1ms, TR 61ms, flip angle 30° and slice thickness = 6 mm. The acquisition parameters in the in-plane sequence were matrix = 192 x 192, TE = 2.1 ms, TR = 48 ms, flip angle = 30° and slice thickness = 5.5 mm. The velocity encoding gradients varied between 250 m/s and 350 m/s. The measurements were performed with Siemens workstation using the Argus cardiac function diagnostics software. In total, flow measurements in 3 patients were made which of 2 had accelerated aortic flow and 1 had accelerated pulmonary flow.

Results: Relative measured through plane net flows are plotted against the distance from the valve (Figure 1). The effect of the acceleration artefacts are clearly present close to the valve. At 2 cm above the valve the measured net flow reaches the maximum with minimum amount of error involved. The net flow results decrease with further distance from the valve.

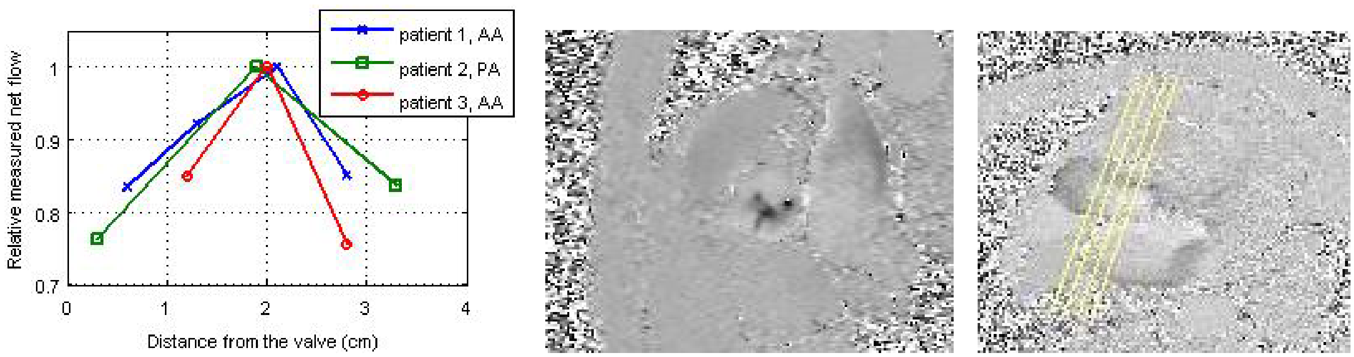

Figure 1. Measured net flows of aortic artery (AA) and pulmonary artery (PA) versus distance to the valve on the left. Example of highly stenotic flow seen in through plane picture in the middle and a representation of measurement plane setup in in-plane picture on the right.

Discussion: Measurement plane position affects highly on measured net flow in patients with accelerated aortic or pulmonary flow. Near the valve the main error factor is the acceleration artefact originating from rapid velocity change in ventricular outflow. The effective range of acceleration artefact can be calculated by multiplying used velocity encoding gradient with used TE. In typical case this range is 1-2 cm from the valve.

The artefacts caused by turbulent flow grow larger in greater distances where the nature of the narrow jet is changing from laminar to more turbulent. The amount of error is hard to predict in this case because the characteristics of the flow are depending on many factors including the present morphology, the speed of the flow and the function of the valve.

To reach minimum amount of error, the measurement plane has to be positioned immediately above the zone where the acceleration artefact is present. On the other hand, the measurement plane has to be positioned close enough to the valve that the artefacts due turbulent flow do not grow to significant number. Usually the optimal position can be determined using simple guidelines, but it might be the case that optimal plane can´t be found and certain level of error has to be accepted.

References: [1] Kilner et al. Journal of Cardiovascular Magnetic Resonance, 2007; 9: 723–728