

RETROGRADE FLOW IN THE VENA CAVA SUPERIOR IS ASSOCIATED WITH INCREASED RIGHT ATRIUM PRESSURE IN PULMONARY ARTERIAL HYPERTENSION

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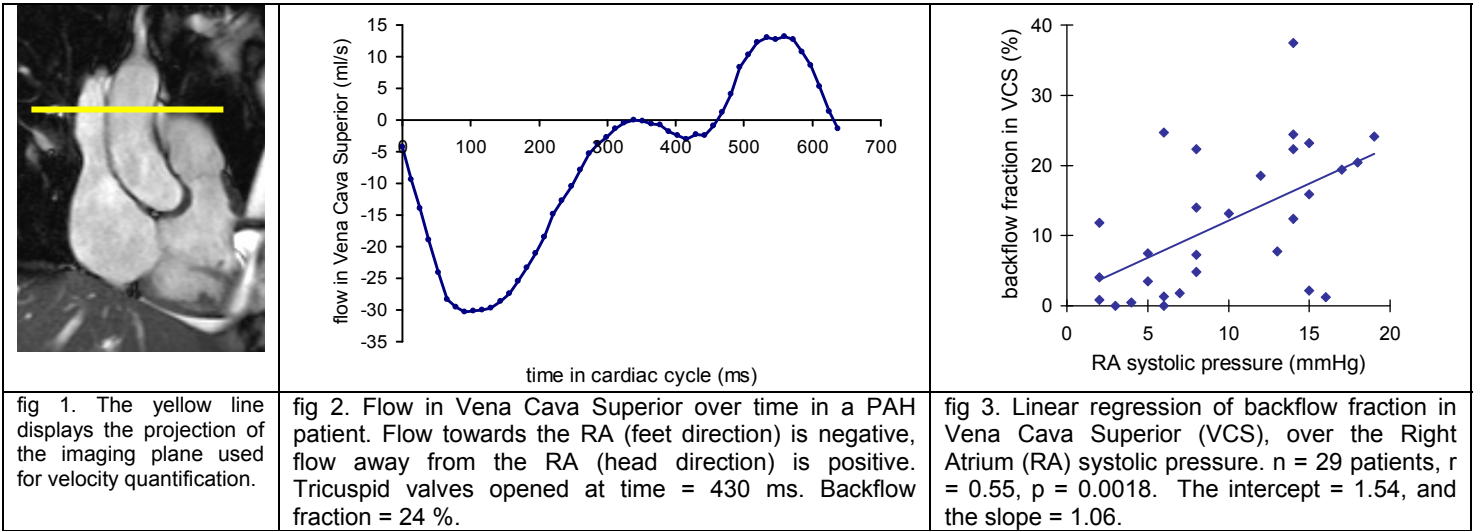
**Introduction** In Pulmonary Arterial Hypertension (PAH), the right atrium (RA) pressure has a significant prognostic value (Benza RL et al., 2010). As yet, the underlying mechanism is not clear. It is possible that an increased RA pressure has a large hemodynamic consequence, because of the low pressure in the Vena Cava and the lack of effective valves between RA and Vena Cava. We hypothesize that backflow in the Vena Cava is associated with increased RA pressure, which may then explain the hemodynamic relevance of increased RA pressure in PAH.

**Objective** The aim of this study is to quantify the backflow in the Vena Cava, and to assess the association between backflow in the Vena Cava and RA pressure in PAH patients.

**Methods** Twenty-nine consecutive patients were suspected of PAH. Cardiac MRI was performed on a Siemens 1.5T 'Avanto' whole body scanner (Siemens Healthcare, Erlangen, Germany) equipped with a 6-element phased-array body coil. In the Vena Cava Superior (VCS), phase-contrast velocity quantification was performed during continuous breathing, using a gradient-echo pulse sequence with through-plane velocity encoding and a velocity sensitivity of 150 cm/sec. Triggering was retrospectively, field of view = 240 × 320 mm<sup>2</sup>, matrix size = 140 × 256, echo time = 3.4 ms, temporal resolution = 13.2 ms, flip angle = 15°. The orientation of the image plane was purely transverse, at the position of the right pulmonary artery (fig 1). The volumetric flow curve in the VCS was calculated. Retrograde (backward) flow was expressed as the volumetric fraction of backward to forward volume, shortly denoted by "backflow fraction".

Within 24 hours time delay after MRI, all patients underwent right heart catheterization during which the RA and pulmonary artery pressures were measured. In this study we used the systolic RA pressure for comparison with the VCS backflow. In the measure of "systolic RA pressure", the label of "systolic" refers to the atrial systole late in the cardiac cycle. Linear regression was applied to explore the association between VCS backflow and RA systolic pressure.

**Results** Out of the 29 patients, 22 were confirmed as having PAH (defined as mean pulmonary artery pressure larger than 25 mmHg). In fig. 2 an example curve is presented of volumetric VCS flow over time in the cardiac cycle. The zero time point is the ECG-R wave. VCS backflow is plotted as positive, and occurs late in the cardiac cycle when the atrial contraction is expected. For all patients, the association between VCS backflow fraction and RA systolic pressure is presented in fig 3. The association is significant with  $r = 0.55$  and  $p = 0.0018$ .



**Discussion** As illustrated in fig 2, the systolic RA pressure, although increased, is still not able to overcome the RV diastolic pressure in those patients with considerable VCS backflow. Instead, the RA contraction results in pumping the blood partly back into the low-pressure Vena Cava. For these patients, the RA contraction is largely contra-productive. With increased RA systolic pressure, the volume of backflow may reach up to 1/4 of forward flow in individual patients. This backflow volume probably can become so large, because there are no effective valves between RA and Vena Cava. Thereby this backflow phenomenon is hemodynamically very disadvantageous, and may well be the explanation for the prognostic value of RA pressure in PAH.

Limitations of this study are the following: So far the backflow was only measured in the VCS, but it should also be quantified in the Vena Cava Inferior. In addition, the Central Venous Pressure should be accounted for, because it is the pressure *gradient* between RA and Vena Cava that determines the flow direction.

**Conclusion** Backward flow in the Vena Cava Superior is associated with increased RA pressure in Pulmonary Arterial Hypertension. This potentially explains, from a hemodynamic point of view, why the RA pressure has a significant prognostic value in PAH.

**Reference:** Benza RL et al, Predicting survival in pulmonary arterial hypertension: insights from the Registry to Evaluate Early and Long-Term Pulmonary Arterial Hypertension Disease Management (REVEAL). Circulation. 2010 Jul 13;122(2):164-72.