Prolonged Right Ventricular post-systolic isovolumic period in Pulmonary Arterial Hypertension: a reflection of diastolic dysfunction?

G. J. Mauritz[1], J. T. Marcus[1], N. Westerhof[1], P. E. Postmus[1], and A. Vonk Noordegraaf[1]
[1]VU University Medical Center, Amsterdam, Netherlands

Background The Right Ventricular (RV) Post-Systolic Isovolumic Period is the time interval between pulmonary valve closure and tricuspid valve opening. In Pulmonary Arterial Hypertension (PAH) this Post-Systolic Isovolumic Period is prolonged, which is *interpreted* as prolonged RV isovolumic relaxation time and thus as a reflection of RV diastolic dysfunction. This interpretation recently was questioned, since it was shown that RV contraction continues after pulmonary valve closure causing a Post-Systolic Contraction Period [1]. We therefore explore in PAH whether the increased RV Post-Systolic Isovolumic Period is caused by, either an increased Relaxation Period, or an increased Contraction Period, or both.

Methods 23 PAH patients (mean pulmonary arterial pressure 54±12 mmHg, by catheterization), and 18 healthy subjects were studied. A 1.5 T 'Sonata' whole body MRI system, equipped with a 6-element phased-array coil, was used (Siemens Medical Solutions, Erlangen, Germany). In a RV two-chamber view, times of pulmonary valve closure and tricuspid valve opening were measured, defining the Post-Systolic Isovolumic Period. MRI myocardial tagging with 14 ms temporal resolution was applied with Complementary Spatial Modulation of Magnetization (7 mm tag distance) and steady state free precession imaging: 3 phase-encoding lines per beat, TR 4.7 ms, TE 2.3 ms, flipangle 20 deg, voxel 1.2 x 3.8 x 6.0 mm^3. Imaging was in the mid-ventricular short-axis plane (fig 1). With tagging, time to peak of RV free wall contraction (T_{peak}RV) was determined. Post-Systolic Contraction and Relaxation Periods were defined as the time intervals between pulmonary valve closure and T_{peak}RV and between T_{peak}RV and tricuspid valve opening, respectively (fig 2). These periods were normalized as fraction of RR interval.

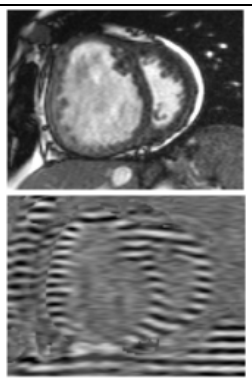

Fig 1. Short-axis cine and tagging cine in PAH, at time of peak RV contraction. Note the leftward septal bowing.

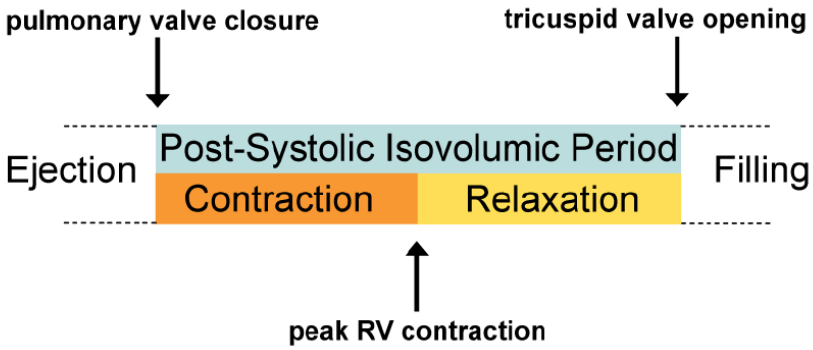

Fig 2. The RV Post-Systolic Isovolumic Period is between pulmonary valve closure and tricuspid valve opening. In PAH, this period starts with an abnormal post-systolic contraction period, followed by a normal relaxation period.

Results The total Post-Systolic Isovolumic Period was longer in patients than healthy subjects (0.15±0.04 vs 0.04±0.02, $p<0.001$), but the Relaxation Period was not different (0.057±0.018 vs 0.047±0.017, $p=0.09$). In the patients, the prolongation of the total Post-Systolic Isovolumic Period was only due to the Post-Systolic Contraction Period, which was closely related to the total Post-Systolic Isovolumic Period ($y=0.98x–0.05$; $r=0.89$, $p<0.001$) and was associated with pulmonary vascular resistance ($p < 0.001$, $r= 0.75$).

Discussion In PAH, the continued contraction of the RV free wall after pulmonary valve closure is possible by the leftward ventricular septum bowing. This leftward septum bowing is enabled by early left ventricular relaxation and pressure decrease [1].

Conclusions In PAH, the RV Post-Systolic Isovolumic Period is prolonged, but this is *not* a prolonged isovolumic *relaxation* time and thus *not* a reflection of diastolic dysfunction. Instead, the prolonged Post-Systolic Isovolumic Period is only caused by an increased Contraction Period, which is associated with disease severity.

This myocardial tagging research has unraveled the underlying mechanism behind the prolonged RV post-systolic isovolumic period in PAH. This period can easily be measured in routine clinical practice from the timing of pulmonary and tricuspid valves, and is informative on the duration of prolonged post-systolic RV contraction which plays such an important role in RV and LV dysfunction in PAH [2].

Reference [1] Marcus JT, Gan CT, Zwanenburg JJ et al. Interventricular mechanical asynchrony in pulmonary arterial hypertension: left-to-right delay in peak shortening is related to right ventricular overload and left ventricular underfilling. J Am Coll Cardiol 2008;51:750-7.
[2] Beyar R. Heart Inefficiency in Pulmonary Hypertension: A Double Jeopardy. J Am Coll Cardiol 2008; 51: 758-9.