# Atrioventricular plane displacement and regional contribution to stroke volume to predict outcome in pulmonary arterial hypertension

A. Lindholm, B. Kjellstrom, F. Seemann, M. Carlsson, R. Hesselstrand, G. Radegran, H. Arheden, E. Ostenfeld

*Skane University Hospital, Lund, Sweden*
On behalf of Lund Cardiac MR Group
**Funding Acknowledgement:** Type of funding sources: Public hospital(s). Main funding source(s): Skåne University Hospital, Region of SkåneSouthern Healthcare Region of Sweden

**Background:** Patients with pulmonary arterial hypertension (PAH) exhibit high mortality, partially related to right heart failure. Right ventricular (RV) volumes and ejection fraction (EF) can be measured accurately with cardiac magnetic resonance (CMR), but EF is a crude measure of cardiac function. Additional methods for risk assessment and prognosis are of value. Stroke volume (SV) is generated by longitudinal, lateral and septal myocardial contraction. Longitudinal contribution to SV (SVlong%) generated from the atrioventricular displacement (AVPD) is the major contributor to SV in both the left ventricle (LV) and RV. AVPD in both sides and LVSVlong% are lower in patients with PAH compared to controls. However, it is unknown if altered AVPD or regional contributions to SV are prognostic in patients with PAH. The aim of this study was therefore to evaluate if AVPD, longitudinal, lateral or septal contribution to LVSV and RVSV are associated with death or lung transplantation in patients with PAH.
**Purpose:** To evaluate if biventricular AVPD, and regional contributions to SV are associated with outcome in patients with PAH.
**Methods:** Seventy-one patients with PAH and 20 sex and age-matched healthy controls underwent CMR. Endocardial and epicardial borders and RV insertion points were defined in end diastole and end systole in cine short-axis stacks to compute biventricular volumes, SVlat% and SVsept%. Eight atrioventricular points were defined in end diastole and end systole in 2-, 3- and 4-chamber cine long-axis views, for computation of AVPD and SVlong%. Cut-off values for survival analysis were defined as above or below mean ± 2 standard deviations from the healthy controls. Outcome was defined as death or lung-transplantation.
**Results:** Median follow-up time was 3.6 [IQR 3.7] years. AVPD, SVlong%, SVlat% in both ventricles and SVsept% were altered in PAH compared to controls. Transplantation-free survival was lower with values below cut-off for LV-AVPD (hazard ratio (HR)=2.1, 95% CI: 1.2–3.9, p=0.02) and RV-AVPD (HR=9.8, 95% CI: 4.6–21.1, p=0.005) (fig 1). In cox regression analysis, decreased LV-AVPD and RV-AVPD inferred lower transplantation-free survival (LV: HR=1.16 per mm decrease, p=0.007; RV: HR=1.11 per mm decrease, p=0.01) (table 1). LVEF, RVEF, LV-SVlong%, RV-SVlong%, LV-SVlat%, RV-SVlat% or SVsept% did not affect outcome (table 1).
**Conclusions:** Decreased left and right AVDP were associated with decreased transplantation-free survival in patients with PAH. There were no associations between ejection fraction, longitudinal, lateral or septal contribution to stroke volume.

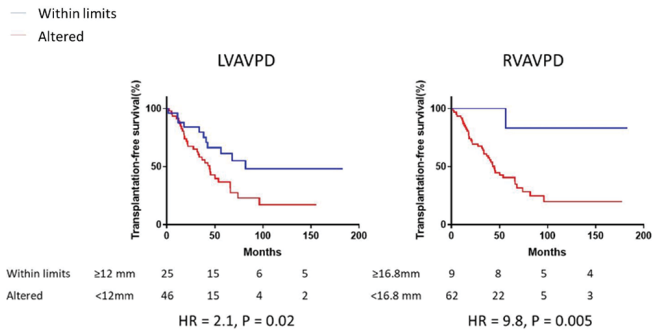


**Figure 1.** Kaplan-Meyer survival analysis of transplantation free survival regarding left ventricular atrio-ventricular plane displacement (LV-AVPD) and right ventricular atrio-ventricular plane displacement (RV-AVPD). The blue lines represent patients with values within limits and the red line patients with altered values.

**Table 1.** Univariate and bivariate (adjusted for age) cox regression analysis for major adverse cardiac event.

| | Univariate HR (95% CI) | Univariate p-value | Bivariate HR (95% CI) | Bivariate p-value |
|---|---|---|---|---|
| LV-AVPD (per 1mm) | 1.16 (1.04-1.28) | **0.007** | 1.16 (1.04-1.29) | **0.008** |
| RV-AVPD (per 1mm) | 1.11 (1.03-1.20) | **0.01** | 1.12 (1.03-1.21) | **0.01** |
| LV-$SV_{long\%}$ (per 1%) | 1.02 (1.00-1.05) | 0.08 | 1.02 (1.00-1.05) | 0.09 |
| RV-$SV_{long\%}$ (per 1%) | 1.01 (1.00-1.03) | 0.1 | 1.01 (1.00-1.03) | 0.2 |
| LV-$SV_{lat\%}$ (per 1%) | 1.00 (0.99-1.03) | 0.3 | - | - |
| RV-$SV_{lat\%}$ (per 1%) | 0.98 (0.96-1.00) | 0.09 | 0.98 (0.96-1.00) | 0.06 |
| $SV_{sept\%}$ (per 1%) | 1.00 (0.98-1.02) | 1.0 | - | - |
| LVEF% (per 1%) | 1.00 (0.96-1.03) | 0.9 | - | - |
| RVEF% (per 1%) | 1.01 (0.98-1.04) | 0.4 | - | - |
| Age (per 1year) | 1.03 (1.01–1.05) | **0.003** | | |

Univariate analysis for increased risk of lung-transplantation or death with continuous variables and bivariate analysis adjusted for age. HR, hazard ratio for decrease in each incremental step; CI, confidence interval; LV-AVPD, left ventricular atrio-ventricular displacement; RV-AVPD, right ventricular atrio-ventricular displacement; LV-$SV_{long\%}$, left ventricular longitudinal contribution to stroke volume; RV-$SV_{long\%}$, right ventricular longitudinal contribution to stroke volume; LV-$SV_{lat\%}$, left ventricular lateral contribution to stroke volume; RV-$SV_{lat\%}$ right ventricular lateral contribution to stroke volume; $SV_{sept\%}$, septal contribution to stroke volume; LVEF, left ventricular ejection fraction; RVEF, right ventricular ejection fraction.