The hemodynamic and prognostic impact of systolic pressure change during right ventricular ejection in patients with HFREF

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Background and purpose: The gold-standard method to evaluate right ventricular (RV) function in pulmonary hypertension (PH) relies on invasive pressure-volume loop (PV-loop) measurement of RV-pulmonary artery (PA) coupling defined as the ratio of end-systolic RV elastance to pulmonary arterial elastance (Ees/Ea). The normal RV PV-loop has a triangular shape with a peaking early systolic pressure (early-SP). With progression of PH the PV-loop changes from trapezoid to a rectangular and ultimately to a trapezoid shape. Along with these geometric changes, the ratio between early-SP and end-systolic pressure (ESP) decreases from >1 to <1 with a late systolic peaking of RV pressure. How all these changes relate to RV afterload, RV-PA coupling, non-invasive RV function, and prognosis in PH due to left heart disease is incomplete understood.

Methods: We analyzed and categorized the conductance catheter-derived single-beat RV PV-loops in 133 patients with HFREF (110 patients: a post-hoc analysis of the Magdeburg CRT Responder Trial, 23 from a local PV-L-derived CRT-optimization trial) according their shape (triangular, rectangular, trapezoid), and determined the early-SP/ESP ratio.

Results: Using multivariate linear regression analysis (adjusted for afterload parameter PVR, PA-compliance, PCWP, PAmean), only PCWP (beta=−0.17) and PA-compliance (beta=0.61) remained significant determinants of the early-SP/ESP ratio and PV-loop shape. In turn, early-SP/ESP ratio seems to be an important determinant of RV-PA coupling efficiency (Ees/Ea) of the RV to afterload (r=0.8, p<0.001). The association between early-SP/ESP ratio and Ees/Ea ratio was closer than Ees/Ea ratio to the other afterload parameters Ea (r=−0.7), PVR (r=−0.41), and PA-compliance (r=0.62). Furthermore, the early-SP/ESP ratio was significantly associated with parameters of non-invasive RV function such as TAPSE (r=0.67), FAC (r=0.76), RVEF (r=0.7), and the non-invasive RV-PA coupling parameter TAPSE/PASP (r=0.8) (all p<0.001). In cox regression analysis, the early-SP/ESP ratio was a strong indicator for long-term survival (median FU 4.2 years) (OR 0.025, CI 95% 0.007–0.09). Simple categorization of the RV PV-loop shapes into “triangular” (early-SP/ESP ratio >1.1, mean survival 7.7 years), “rectangular” (0.9–1.1, 6.4 years) and “trapezoid” (<0.9, 3.2 years) clearly differentiated long-term survival of HFREF patients (log rank, Chi square 50.1, p<0.001).

Conclusion: The early-SP/ESP ratio determines the shape of RV-PV-loops and is closely associated with predominately pulsatile PA load, RV-PA coupling capacity, RV function, and long-term prognosis of patients with HFREF.