**Supplemental online material to**

**Prognostic relevance of the Right Ventricular Myo-mechanical Index (RV-MMI)**

**in patients with precapillary pulmonary hypertension**

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**Figure legends**

**Figure A. Effective RV performance and associated surrogate parameters.**

Abbreviations:RV right ventricular, EDD enddiastolic diameter, RA-ESA right atrial end-systolic area, BSA body surface area, IVC vena cava inferior, RAP right atrial pressure, FAC fractional area change, EF ejection fraction, ASI automated systolic index, MPI myocardial performance index, TASV tricuspid annular systolic velocity, TAPSE tricuspid annular plane systolic excursion, LV-EI left ventricular eccentricity index, m/sPAP mean/systolic pulmonary arterial pressure, PVR pulmonary vascular resistance, mPG mean pressure gradient.

**Figure B1-12. Diagnostic accuracy and predictive information upon survival by established**

**surrogate parameters for RV function, LV-EF, NTproBNP and cTnT.**

Abbreviations: ROC receiver-operator-characteristics, AUC area under the curve, CI confidence interval, sens sensitivity, spec specificity, HR hazard ratio, RA-ESA right atrial end-systolic area, BSA body surface area, RV right ventricular, FAC fractional area change, ASI automated systolic index, LV-EI left ventricular eccentricity index, TAPSE tricuspid annular plane systolic excursion, TASV tricuspid annular systolic velocity, MPI myocardial performance index, LV-EF left ventricular ejection fraction, NTproBNP N-terminal pro-brain natriuretic peptide, cTnT cardiac troponin T.

**Figure C. RV-MMI in context to time and possible course of disease.**

For each course of disease at least the three main factors for alteration of effective RV function have to be considered: RV-mPG for afterload, RA-ESA(BSA) for preload, and RV-2Dstrain (ε) for RV contractility. Abbreviations: RV-MMI right ventricular myo-mechanical index, RV right ventricular, mPG mean pressure gradient, RA-ESA right atrial end-systolic area, BSA body surface area, ε RV-2Dstrain, PH pulmonary hypertension, mPAP mean pulmonary arterial pressure, RHC right heart catheter, sPAP mean pulmonary arterial pressure.

**Figure A – Effective RV performance with association to surrogate parameters**

**figA.tif**

**Figure B1. Diagnostic accuracy and prediction of survival by RA-ESABSAfigB1.tif**

**Figure B2. Diagnostic accuracy and prediction of survival by RV-FAC figB2.tif**

**Figure B3. Diagnostic accuracy and prediction of survival by RV-ASIfigB3.tif**

**Figure B4. Diagnostic accuracy and prediction of survival by LV-EIfigB4.tif**

**Figure B5. Diagnostic accuracy and prediction of survival by TAPSEfigB5.tif**

**Figure B6. Diagnostic accuracy and prediction of survival by TASVfigB6.tif**

**Figure B7. Diagnostic accuracy and prediction of survival by Tei-Index (MPI RV) figB7.tif**

**Figure B8. Diagnostic accuracy and prediction of survival by dp/dt (RV)figB8.tif**

**Figure B9. Diagnostic accuracy and prediction of survival by RV-2DstrainfigB9.tif**

**Figure B10. Diagnostic accuracy and prediction of survival by LV-EFfigB10.tif**

**AUC= 0,85 95%CI= 0,76-0,95 p< 0,001 c/o≤ 0,31 SE= 0,05**

**Figure B11. Diagnostic accuracy and prediction of survival by NTproBNPfigB11.tif**

**AUC= 0,85 95%CI= 0,76-0,95 p< 0,001 c/o≤ 0,31 SE= 0,05**

**Figure B12. Diagnostic accuracy and prediction of survival by cTnTfigB12.tif**

**AUC= 0,85 95%CI= 0,76-0,95 p< 0,001 c/o≤ 0,31 SE= 0,05**

**Figure C. RV-MMI in context to time and possible course of disease.**

**fig5.tif**

**Table D - Univariate survival analysis by Cox proportional regression with steadily inclusion of measured parameters for all patients (n=65)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  |  | |  | | **HR** | | **95% CI** | | | **χ2** | |  | |
| Age, y |  | |  | |  | | 1.00 | | 0.97 | 1.04 | | **-** | |  | |
| Sex, female |  | |  | |  | | 0.37ns | | 0.14 | 1.00 | | **4.1\*** | |  | |
| BMI, kg/m2 |  | |  | |  | | 0.98ns | | 0.89 | 1.09 | | **-** | |  | |
| BSA, m2 |  | |  | |  | | 2.74ns | | 0.27 | 27.8 | | **-** | |  | |
| Heart rate, /min |  | |  | |  | | **4.3\*\*** | | 1.5 | 12.4 | | **8.6\*\*** | |  | |
| Hemoglobine, g/dL |  | |  | |  | | 0.99ns | | 0.93 | 1.05 | | **-** | |  | |
| WHO FC |  | |  | |  | | 1.60ns | | 0.83 | 3.08 | | **-** | |  | |
| 6MWT, m |  | |  | |  | | 1.00ns | | 0.99 | 1.00 | | **-** | |  | |
| NTproBNP, pg/L |  | |  | |  | | **1.10\*\*** | | 1.03 | 1.18 | | **8.8\*\*** | |  | |
| cTnT, ng/L |  | |  | |  | | **1.01\*\*** | | 1.00 | 1.01 | | **11.4\*\*** | |  | |
| LV-EF, % |  | |  | |  | | **1.1\*\*** | | 1.04 | 1.24 | | **8.4\*\*** | |  | |
| IVC diameter, mm |  | |  | |  | | 1.05ns | | 0.95 | 1.17 | | **-** | |  | |
| IVC collapsibility, <50% |  | |  | |  | | 1.49ns | | 0.55 | 4.00 | | **-** | |  | |
| RA-ESA, cm2 |  | |  | |  | | **1.08\*\*** | | 1.03 | 1.14 | | **8.9\*\*** | |  | |
| RA-ESABSA, cm2/m2 |  | |  | |  | | **1.17\*\*** | | 1.05 | 1.31 | | **8.8\*\*** | |  | |
| RV-EDD, mm |  | |  | |  | | **1.06\*\*** | | 1.02 | 1.10 | | **7.1\*\*** | |  | |
| RV-ESA, cm2 |  | |  | |  | | **1.03\*** | | 1.01 | 1.06 | | **7.5\*\*** | |  | |
| RV-EDA, cm2 |  | |  | |  | | **1.03\*** | | 1.01 | 1.06 | | **7.1\*\*** | |  | |
| TAPSE, mm |  | |  | |  | | **0.86\*** | | 0.76 | 0.97 | | **6.3\*** | |  | |
| RV-FAC, % |  | |  | |  | | 0.97ns | | 0.93 | 1.02 | | **-** | |  | |
| RV-ASI, % |  | |  | |  | | **0.96** | | 0.92 | 0.99 | | **5.7\*** | |  | |
| LV-EI |  | |  | |  | | **1.22\*\*\*** | | 1.09 | 1.37 | | **14.6\*\*\*** | |  | |
| TR, severe |  | |  | |  | | 1.11ns | | 0.29 | 4.22 | | **-** | |  | |
| TR, late systolic peak velocity |  | |  | |  | | 1.14ns | | 0.24 | 5.31 | | **-** | |  | |
| dt to peak systole, ms |  | |  | |  | | 1.00ns | | 0.99 | 1.00 | | **-** | |  | |
| dt to peak (corr HF), ms |  | |  | |  | | 1.00ns | | 1.00 | 1.01 | | **-** | |  | |
| dt systole, ms |  | |  | |  | | 0.99ns | | 0.98 | 1.00 | | **-** | |  | |
| dt systole (corr HF), ms |  | |  | |  | | 0.99ns | | 0.99 | 1.01 | | **-** | |  | |
| TR mean acceleration, m/s2 |  | |  | |  | | 1.07 | | 0.98 | 1.17 | | **-** | |  | |
| dt1 (accel 4>36 mm Hg), ms |  | |  | |  | | 1.00ns | | 0.99 | 1.00 | | **-** | |  | |
| dt2 (accel 4>16 mm Hg) , ms |  | |  | |  | | 1.00ns | | 0.97 | 1.04 | | **-** | |  | |
| dt3 (accel 2>16 mm Hg) , ms |  | |  | |  | | 1.01ns | | 0.98 | 1.03 | | **-** | |  | |
| dt1/dp, ms / mm Hg |  | |  | |  | | 1.00ns | | 1.00 | 1.00 | | **-** | |  | |
| dt2/dp, ms / mm Hg |  | |  | |  | | 1.00ns | | 1.00 | 1.00 | | **-** | |  | |
| dt3/dp, ms / mm Hg |  | |  | |  | | 1.00ns | | 1.00 | 1.00 | | **-** | |  | |
| RV-mPG, mm Hg |  | |  | |  | | 0.99ns | | 0.96 | 1.02 | | **-** | |  | |
| RV-sPG, mm Hg |  | |  | |  | | 0.99ns | | 0.98 | 1.01 | | **-** | |  | |
| RAP, mm Hg |  | |  | |  | | 1.07ns | | 0.99 | 1.16 | | **-** | |  | |
| sPAP, mm Hg |  | |  | |  | | 1.00ns | | 0.98 | 1.02 | | **-** | |  | |
| TASV, cm/s |  | |  | |  | | 1.03 | | 0.91 | 1.16 | | **-** | |  | |
| IVRT, ms |  | |  | |  | | 1.01 | | 1.00 | 1.02 | | - | |  | |
| Tei-Index |  | |  | |  | | 1.94ns | | 0.66 | 5.74 | | - | |  | |
| RV-2Dstrain, -% |  | |  | |  | | **0.88\*\*** | | 0.81 | 0.96 | | **9.5\*\*** | |  | |
| RV-MMI, mmHg\*% |  | |  | |  | | **0.66\*\*** | | 0.49 | 0.90 | | **7.9\*\*\*** | |  | |

**Abbreviations:** HR hazard ratio, 95%CI 95% confidence interval, BMI body mass index, BSA body surface area, FC functional class, 6MWT 6-minute walk test, NTproBNP N-terminal pro-brain natriuretic peptide, cTnT cardiac troponin T, LV-EF left ventricular ejection fraction, IVC vena cava inferior, RA-ESA right atrial end-systolic area, RV right ventricular, EDD enddiastolic diameter, ESA endsystolic area, EDA enddiastolic area, TAPSE tricuspid annular plane systolic excursion, FAC fractional area change, ASI automated systolic index, LV-EI left ventricular eccentricity index, TR tricuspid regurgitation, corr HF corrected for heart frequency, accel acceleration, mPG mean pressure gradient, sPG systolic pressure gradient, RAP right atrial pressure, sPAP systolic pulmonary arterial pressure, TASV tricuspid annular systolic velocity, IVRT isovolumetric contaction time, RV-MMI right ventricular myo-mechanical index. nsnot significant, \*p<0.05, \*\*p<0.01, \*\*\*p<0.001

**Table E - Univariate survival analysis by Cox proportional regression with steadily inclusion of measured parameters for patients without severe TR (n=52)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  |  | |  | | **hazard ratio** | | **95% CI** | | | **χ2** | |  | |
| Age, y | |  |  | |  | | 1.01ns | | 0.97 | 1.06 | | **-** | |  | |
| Sex | |  |  | |  | | 0.37ns | | 0.13 | 1.11 | | **-** | |  | |
| BMI, kg/m2 | |  |  | |  | | 0.98ns | | 0.88 | 1.90 | | **-** | |  | |
| BSA, m2 | |  |  | |  | | 2.67ns | | 0.20 | 35.25 | | **-** | |  | |
| Heart rate, /min | |  |  | |  | | **1.05\*\*** | | 1.01 | 1.08 | | **7.9\*\*** | |  | |
| Hemoglobine, g/dL | |  |  | |  | | 0.97ns | | 0.83 | 1.13 | | **-** | |  | |
| WHO FC | |  |  | |  | | 1.72ns | | 0.85 | 3.49 | | **-** | |  | |
| 6MWT, m | |  |  | |  | | 0.99ns | | 0.99 | 1.00 | | **-** | |  | |
| NTproBNP, pg/L | |  |  | |  | | **1.12\*\*** | | 1.04 | 1.20 | | **13.4\*\*\*** | |  | |
| cTnT, ng/L | |  |  | |  | | **1.01\*\*** | | 1.00 | 1.0.1 | | **10.8\*\*** | |  | |
| LV-EF, % | |  |  | |  | | **1.14\*\*** | | 1.04 | 1.25 | | **8.7\*\*** | |  | |
| IVC diameter, mm | |  |  | |  | | 1.04ns | | 0.93 | 1.17 | | **-** | |  | |
| IVC collapsibility, <50% | |  |  | |  | | 2.44ns | | 0.82 | 7.23 | | **-** | |  | |
| RA-ESA, cm2 | |  |  | |  | | **1.08\*** | | 1.01 | 1.16 | | **4.9\*** | |  | |
| RA-ESABSA, cm2/m2 | |  |  | |  | | **1.18\*** | | 1.01 | 1.38 | | **4.5\*** | |  | |
| RV-EDD, mm | |  |  | |  | | 1.07ns | | 1.00 | 1.10 | | **-** | |  | |
| RV-ESA, cm2 | |  |  | |  | | 1.08ns | | 1.00 | 1.16 | | **-** | |  | |
| RV-EDA, cm2 | |  |  | |  | | 1.06ns | | 0.99 | 1.13 | | **-** | |  | |
| TAPSE, mm | |  |  | |  | | **0.82\*\*** | | 0.70 | 0.94 | | **7.5\*\*** | |  | |
| RV-FAC, % | |  |  | |  | | 0.97ns | | 0.90 | 1.03 | | **-** | |  | |
| RV-ASI, % | |  |  | |  | | 0.97ns | | 0.93 | 1.01 | | **-** | |  | |
| LV-EI | |  |  | |  | | **1.25\*\*** | | 1.10 | 1.42 | | **13.8\*\*\*** | |  | |
| TR, late systolic peak velocity | |  |  | |  | | 1.25ns | | 0.54 | 2.89 | | **-** | |  | |
| dt to peak systole, ms | |  |  | |  | | 0.99ns | | 0.99 | 1.00 | | **-** | |  | |
| dt to peak (corr HF), ms | |  |  | |  | | 1.00ns | | 0.99 | 1.01 | | **-** | |  | |
| dt systole, ms | |  |  | |  | | 0.99ns | | 0.98 | 1.00 | | **-** | |  | |
| dt systole (corr HF), ms | |  |  | |  | | 1.00ns | | 1.00 | 1.01 | | **-** | |  | |
| TR mean acceleration, m/s2 | |  |  | |  | | 1.07ns | | 0.98 | 1.17 | | **-** | |  | |
| dt1 (accel 4>36 mm Hg), ms | |  |  | |  | | 1.00ns | | 0.99 | 1.01 | | **-** | |  | |
| dt2 (accel 4>16 mm Hg) , ms | |  |  | |  | | 1.00ns | | 0.96 | 1.04 | | **-** | |  | |
| dt3 (accel 2>16 mm Hg) , ms | |  |  | |  | | 1.00ns | | 0.98 | 1.03 | | **-** | |  | |
| dt1/dp, ms / mm Hg | |  |  | |  | | 1.00ns | | 1.00 | 1.00 | | **-** | |  | |
| dt2/dp, ms / mm Hg | |  |  | |  | | 1.00ns | | 1.00 | 1.00 | | **-** | |  | |
| dt3/dp, ms / mm Hg | |  |  | |  | | 1.00ns | | 1.00 | 1.00 | | **-** | |  | |
| RV-mPG, mm Hg | |  |  | |  | | 0.99ns | | 0.95 | 1.02 | | **-** | |  | |
| RV-sPG, mm Hg | |  |  | |  | | 0.99ns | | 0.97 | 1.01 | | **-** | |  | |
| RAP, mm Hg | |  |  | |  | | 1.06ns | | 0.98 | 1.16 | | **-** | |  | |
| sPAP, mm Hg | |  |  | |  | | 1.00ns | | 0.98 | 1.02 | | **-** | |  | |
| TASV, cm/s | |  |  | |  | | 1.09ns | | 0.95 | 1.26 | | **-** | |  | |
| IVRT, ms | |  |  | |  | | 1.01ns | | 1.00 | 1.02 | | - | |  | |
| Tei-Index | |  |  | |  | | 3.2ns | | 0.70 | 15.14 | | **-** | |  | |
| RV-2Dstrain, -% | |  |  | |  | | **0.88\*\*** | | 0.80 | 0.96 | | **8.6\*\*** | |  | |
| RV-MMI, mmHg\*% | |  |  | |  | | **0.68\*** | | 0.50 | 0.93 | | **6.6\*\*** | |  | |

**Abbreviations:** HR hazard ratio, 95%CI 95% confidence interval, BMI body mass index, BSA body surface area, FC functional class, 6MWT 6-minute walk test, NTproBNP N-terminal pro-brain natriuretic peptide, cTnT cardiac troponin T, LV-EF left ventricular ejection fraction, IVC vena cava inferior, RA-ESA right atrial end-systolic area, RV right ventricular, EDD enddiastolic diameter, ESA endsystolic area, EDA enddiastolic area, TAPSE tricuspid annular plane systolic excursion, FAC fractional area change, ASI automated systolic index, LV-EI left ventricular eccentricity index, TR tricuspid regurgitation, corr HF corrected for heart frequency, accel acceleration, mPG mean pressure gradient, sPG systolic pressure gradient, RAP right atrial pressure, sPAP systolic pulmonary arterial pressure, TASV tricuspid annular systolic velocity, IVRT isovolumetric contraction time, RV-MMI right ventricular myo-mechanical index. nsnot significant, \*p<0.05, \*\*p<0.01, \*\*\*p<0.001