The ratio of pulmonary artery diameter to Aortic diameter can predict right heart failure after left ventricular assist device implantation

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Background

✓ Right heart failure (RHF) is a major contributor of significant morbidity and mortality in patients with left ventricular assist device (LVAD.

✓ Some hemodynamic parameters have been reported to be predictive of RHF after LVAD implantation, however these are not sufficient in clinical use.

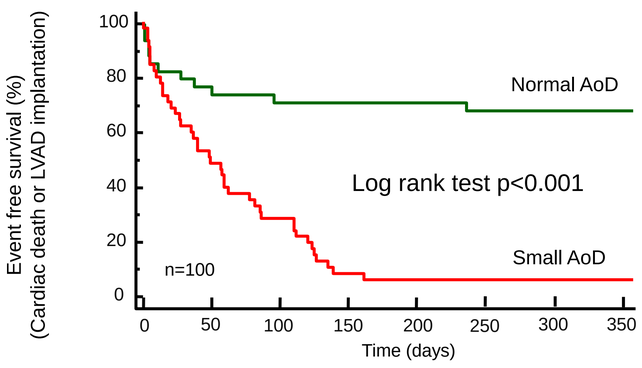
Area under the ROC curve of the predictors for RHF

	AUC
RVSWI	0.63
PVR	0.50
TPG	0.56
sPAP	0.59
RAP	0.53

RVSWI, right ventricular stroke work index; PVR, pulmonary vascular resistance; TPG, trans pulmonary gradient; sPAP, systolic pulmonary artery pressure; RAP, right atrial pressure

Matthews J. et al. J Am Coll Cardiol 2008; 51: 2163-72.

✓ Severe HF patients with dilated cardiomyopathy who had a small ascending aortic diameter (AoD) had worse outcomes.



Chimura M,Nakamoto K, et al. AHA scientific meeting 2016
Chimura M,Nakamoto K, et al. Under Review

✓ Pulmonary artery diameter (PAD) is larger in patients with pulmonary artery hypertension (PH) than in those without.

	PH (mPAP>25mmHg)	No-PH (mPAP≤25mmHg)	P value
Age (yrs)	59±15	64±16	0.19
Male (%)	57	52	0.69
BSA	1.9±0.3	1.8±0.3	0.07
PAD (mm)	32.2±5.3	29.0±3.9	0.002

Chan AL. et al. BMC Medical Imaging 2011;11:7

Aim

To assess the predictive indices for RHF including PAD and AoD which were measured by computerized tomography in LVAD patients.

Methods

Study Subjects

142 patients who underwent LVAD implantation
at Osaka University Hospital from Dec. 2009 to Dec. 2016

Exclusion criteria
- Acute Myocarditis
- No CT examination or technically inappropriate images
- Already on temporary LVAD at the time of CT examination

103 patients

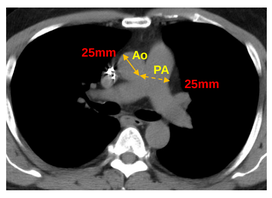
Data of echocardiography and right heart catheterization was obtained before LVAD implantation.

Definition of RHF

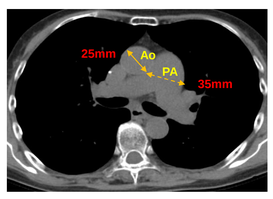
- Need for a subsequent right ventricular assist device (RVAD)
- More than 30 days use of intravenous inotropes and/or pulmonary vasodilators after LVAD implantation.

Measurement of AoD and by CT scan

- 320-detector row CT scanner or dual source CT scanner
- 5-mm slice thickness



Normal PA



Enlarged PA

PAD , AoD and their ratio (PAD/AoD) were measured at the level of the pulmonary artery bifurcation on a transverse CT image before LVAD implantation.

Results

Patient characteristics

	RHF (n=26)	No-RHF (n=77)	*p* value
Age (years)	41±17	43±14	0.65
Male, n (%)	15 (58)	55 (71)	0.24
BSA (m^2)	1.56±0.18	1.64±0.20	0.11
Etiology of cardiomyopathy			
DCM / dHCM / ICM / others, n	10 / 11 / 3 / 2	57 / 6 / 7 / 7	<0.01
Hypertension, n (%)	9 (35)	29 (38)	0.10
Diabetes mellitus, n (%)	7 (29)	13 (17)	0.18
Follow-up duration (years)	11.2±9.8	8.5±7.0	0.13
Medications			
Beta-blockers, n (%)	21 (83)	66 (86)	0.76
ACEI and/ or ARB, n (%)	13 (50)	53 (69)	0.09
Mineralocorticoid receptor antagonists, n (%)	21 (83)	62 (81)	0.78
Diuretics, n (%)	24 (92)	64 (83)	0.32

BSA, body surface area; DCM, dilated cardiomyopathy; dHCM, dilated phase hypertrophic cardiomyopathy; ICM, ischemic cardiomyopathy; ACE, angiotensin converting enzyme; ARB, angiotensin receptor blocker

Within 26 patients with RHF, RVAD support was needed in 10 patients.

Cardiac function

	RHF (n=26)	No-RHF (n=77)	*p* value
Preoperative echocardiography			
LVDD (mm)	66.5±12.8	73.3±10.7	<0.01
LVEF (%)	21.5±10.8	19.3±7.8	0.27
RVDD (mm)	39.1±12.9	41.2±10.5	0.53
TR grade (moderate or severe)	7 (27)	18 (23)	0.42
Preoperative hemodynamic parameters			
Systolic BP, (mmHg)	92.5±13.6	90.4±11.9	0.49
Mean PAP, (mmHg)	29.5±9.0	29.0±10.0	0.83
PAWP, (mmHg)	20.7±7.4	20.2±8.8	0.42
Cardiac Index, (l/min/m^2)	2.3±0.7	2.3±0.6	0.97
PVR, (W.U.)	2.7±1.3	2.3±1.3	0.20
RAP, (mmHg)	9.7±5.1	7.4±5.4	0.07
RVSWI, (mmHg/ml/m^2)	571±236	610±298	0.60
RAP/PAWP ratio	0.48±0.22	0.34±0.20	<0.05

LVDD, left ventricular diastolic diameter; LVEF, left ventricular ejection fraction; LAD, left atrium diameter; RVDD, right ventricular diastolic diameter; TR, tricuspid valve regurgitation; PAP, pulmonary artery pressure; PAWP, pulmonary artery wedge pressure; PVR, pulmonary vascular resistance; RAP, right atrial pressure; RVSWI, right ventricular stroke work index

The patients with RHF had a smaller LVDd, a higher right atrial pressure to pulmonary artery wedge pressure ratio (RAP/PAWP) than those without RHF.

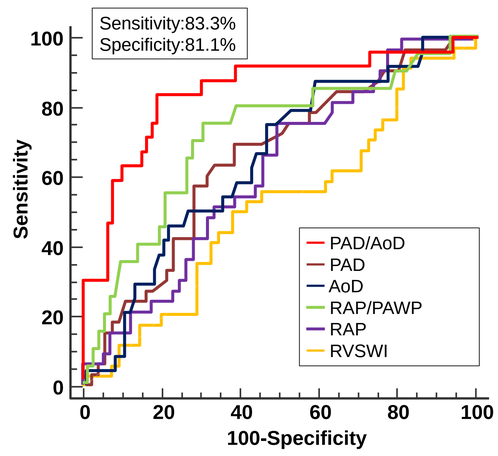
CT measurements

	RHF (n=26)	No-RHF (n=77)	*p* value
AoD(mm)	23.7±3.8	25.9±4.3	<0.05
PAD (mm)	29.5±3.6	27.7±4.0	<0.05
PAD/AoD	1.27±0.20	1.08±0.10	<0.01

AoD, aortic diameter; PAD, pulmonary artery diameter

The patients with RHF had smaller AoD, larger PAD and higher PAD/AoD ratio than those without RHF.

ROC curves of various predictors for RHF



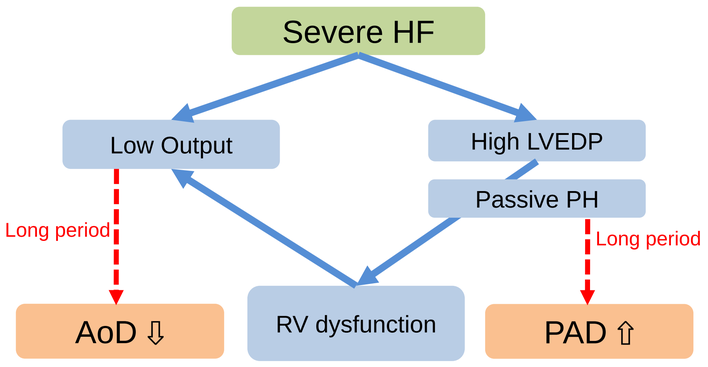
	AUC
PAD/AoD	0.834
RAP/PAWP	0.710
RAP	0.643
PAD	0.638
AoD	0.651
RVSWI	0.520

AoD, aortic diameter; PAD, pulmonary artery diameter; RAP, right atrial pressure ; PAWP, pulmonary artery wedge pressure; RVSWI, right ventricular stroke work index

The receiver operating characteristic curve of PAD/AoD ratio shows a better predictability of RHF than other hemodynamic predictors.

Discussion

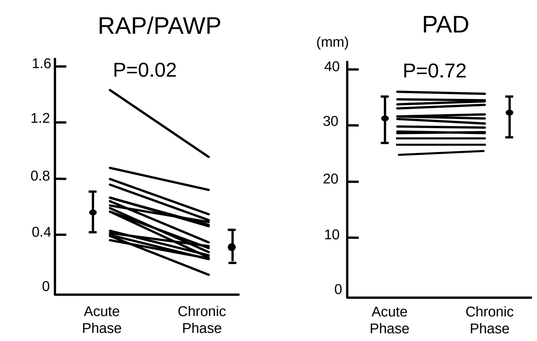
AoD and PAD in severe HF



Severe HF patients who need LVAD usually have decreasing cardiac output and elevated left ventricular pressure at end-diastole (LVEDP). High LVEDP causes passive pulmonary hypertension (PH), and persistent PH will make RV dysfunction

Small AoD may reflect low cardiac output for a long period, and large PAD may reflect PH for a long period. Therefore, PAD/AoD could predict RHF after LVAD implantation.

PAD is not affected by hemodynamics



The RAP/PAWP changed significantly between acute and chronic phase, however PAD did not.

Other predictors for RHF will be affected by temporary hemodynamic changes, and the values will be variable in various HF conditions. However, PAD is less hemodynamic independent. Therefore, PAD/AoD is likely to be a better index for predicting RHF after LVAD implantation than other indices.

Conclusion

PAD/AoD is a simple and better index for predicting RHF after LVAD implantation.

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Presenting Author : Kei Nakamoto
I will not discuss off label use and/or investigational use of the following drugs/devices: OCT and 10% low molecular weight dextran
The following relevant financial relationships exist related to my role in this session: No relationships to disclose.