SPECKLE-TRACKING ECHOCARDIOGRAPHY AND RIGHT VENTRICULAR FUNCTION: AN ADDRESSED VALUE?

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RIGHT VENTRICLE

Not anymore an innocent bystander of the left

Important prognostic value:

- after acute myocardial infarction
- heart failure
- valvular heart disease
- congenital heart disease (Fallot)
- pulmonary hypertension
- after cardiac transplantation

Hochreiter C. Circulation 1986
Pfisterer M et al. Eur Heart J 1986
Bhatia SJS et al. Circulation 1994
Di Salvo TG et al. JACC 1995
Van Straten A et al. Eur Radiol 2005
Nath J et al. Echocardiography 2005

University of Padua
ASSESSMENT OF RIGHT VENTRICULAR FUNCTION IN CLINICAL SETTINGS

Shift from qualitative to quantitative RV study
Challenges for conventional echocardiography

- thin-walled chamber behind the sternum  (several views needed)
- separate inflow and outflow portions  (non-simultaneously imaged)
- asymmetrical, crescentic shape, wrapped around LV  (difficult to describe by any simple geometric model)
- variations of shape with loading conditions
- heavily trabeculated  (poor reproducibility of endocardial tracing)
ECHO ASSESSMENT OF RIGHT VENTRICLE

**1D**
- M-mode (RV diameters, RV wall thickness, TAPSE, septal motion pattern)

**2D**
- RV diameters, areas and wall thickness (*1D measures*)
- Fractional area change (FAC)
- RV ejection fraction (RVEF)

**Doppler**
- Spectral (RV dp/dt, Tei index, diastolic fx, RV systolic pressure)
- TDI (Tei index, S velocity, diastolic fx, strain/strain-rate)

**STE**
- Strain/strain-rate

**3D**
- RV volumes
- RVEF
- RV shape and mass
CLINICAL CASE: 56 y/o man

- Severe porto-pulmonary hypertension (pressure and volume overload)
- Significant tricuspid regurgitation and increased RA pressure

TAPSE 24 mm

RV S wave 12.5 cm/s
RV FUNCTION BEFORE AND AFTER PULMONARY ENDARTERECTOMY
DEFORMATION IMAGING DESCRIBES RV FUNCTION BETTER THAN TAPSE

TAPSE
LV apex displacement
Midwall RV strain
Basal RV strain

preoperative 1 week 6 months

5mm
10%
• Angle-independent
• Sensitive measure of global and segmental longitudinal RV function
• Discriminates true myocardial deformation from displacement and tethering
• Less load dependent than velocities and EF
• Provides both regional amplitude and timing (RV dyssynchrony)
RV LONGITUDINAL STRAIN RATE

Normal subject
## RV LONGITUDINAL STRAIN

### Reference ranges

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PLSS</th>
<th>Range</th>
<th>Time to PLSS</th>
<th>Range</th>
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<tr>
<td><strong>N=100</strong></td>
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<td></td>
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<tr>
<td>Global</td>
<td>-24.2 ± 2.9</td>
<td>-30.0 to -17.7</td>
<td>387 ± 39</td>
<td>302 to 474</td>
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<td>Free wall</td>
<td>-28.7 ± 4.1%</td>
<td>-37.7 to -19.8</td>
<td>388 ± 43</td>
<td>287 to 482</td>
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<td>Septum</td>
<td>-19.8 ± 3.4%</td>
<td>-27.0 to -12.8</td>
<td>385 ± 42</td>
<td>288 to 480</td>
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<td>-43.2 to -14.9</td>
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<td>284 to 511</td>
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<td>-40.9 to -20.1</td>
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<td>Apical free wall</td>
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<tr>
<td>Apical septum</td>
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<td>-33.6 to -9.7</td>
<td></td>
<td>294 to 467</td>
</tr>
</tbody>
</table>

Adapted after Meris A et al. J Am Soc Echocardiogr 2010
RV LONGITUDINAL STRAIN

Discrimination between normal and abnormal function

Meris A et al. J Am Soc Echocardiogr 2010
ECHO ASSESSMENT OF RV FUNCTION

Volume vs pressure RV overload

Control

Tricuspid Reg.

PAH

TAPSE 24 mm

TAPSE 18 mm

TAPSE 18 mm
ECHO ASSESSMENT OF RV FUNCTION

Volume vs pressure RV overload

Control
Global L Strain = -22%
Normal

Tricuspid Reg.
Global L Strain = -22.7%
Volume overload

PAH
Global L Strain = -13.8%
Pressure overload

84 ms
ECHO ASSESSMENT OF RV FUNCTION

Volume vs pressure RV overload

Control

- EDV = 77 ml
- ESV = 28 ml
- RVEF = 64%

Tricuspid Reg.

- EDV = 140 ml
- ESV = 68 ml
- RVEF = 52%

PAH

- EDV = 113 ml
- ESV = 78 ml
- RVEF = 31%
RV FUNCTION IN PULMONARY HYPERTENSION

Case #1 (NYHA III-IV)

Case #2 (NYHA II)

PAPm = 58 mmHg

PAPm = 56 mmHg
RV FUNCTION IN PULMONARY HYPERTENSION

Case #1

GLS = -10.7%

Case #2

GLS = -18.8%
RV FUNCTION IN PULMONARY HYPERTENSION

Case #2
RV DYSFUNCTION IN PULMONARY HYPERTENSION

• the main cause of death of PAH patients (70% of all deaths)

• associated with very poor prognosis

• conventional echo indices reflect RV dysfx only in advanced stages, when disease-targeted therapy has a limited efficacy

• STE could aid in understanding the highly variable adaptation of RV to pressure overload and explain discrepancies in functional capacity and outcome (Eisenmenger vs PAH)

REGIONAL DEFORMATION DIFFERENCES

Severe PAH

Severe secondary PH in DCM
RV DEFORMATION IN PULMONARY EMBOLISM

“60/60” sign

McConnell sign
ECHO ASSESSMENT OF RIGHT VENTRICLE

- RV function impairment is only about a reduced pump function?

- Could echo identify subtle RV impairment before the RV systolic dysfunction becomes apparent?

- RV diastolic function

- RV dyssynchrony
RV DIASTOLIC FUNCTION

Much more than RV wall thickness

Assessing and grading RV diastolic function *should be considered* in patients with suspected RV impairment as:

- marker of *early or subtle RV dysfunction*
- marker of poor prognosis in patients with known RV impairment

Rudsky LG et al. *J Am Soc Echocardiogr* 2010
EARLY DIASTOLIC DYSFUNCTION IN PAH

TAPSE 23 mm

Global RV strain -23%

Global RV strain rate

SRa

SRe

SRs

S = 12 cm/s

E A

E' A'

GS = -22.9%
RIGHT VENTRICULAR DYSSYNCHRONY

Timing is also important

• Both acute and chronic RV pressure overload have been associated with discoordinated RV longitudinal contraction.

• In pulmonary hypertension, RV dyssynchrony correlated with RV dysfunction (Tei index, FAC, GLS), disease severity and functional capacity.

• RV dyssynchrony becomes evident even in mild PH when standard echo indices of RV size and function (TAPSE, FAC) are still normal.

Lopez-Candales A et al. Echocardiography 2007
Dyssynchronous longitudinal contraction could further impair RV function in addition to the actual decrease in contractility and may contribute to the observed discrepancy between regional and global parameters of RV function.
CONCLUSIONS

• Current echo techniques allow a tailored quantitative approach for the assessment of RV size and function

• A multi-parameter approach and the advanced technologies (STE, 3DE) can compensate for the flaws of single conventional indices of RV function

• RV diastolic function and dyssynchrony could provide novel insights in RV function impairment early in disease course

• Further outcome studies are needed to certify the clinical value of novel echo methods over the conventional RV indices