MHIF FEATURED STUDY: Rhapsody

DESCRIPTION:
First multinational, phase 3, double-blinded, placebo-controlled, randomized withdrawal, study assessing the efficacy of rilonacept, an interleukin 1 alpha and beta receptor decoy, in the treatment of recurrent pericarditis.

CRITERIA LIST/QUALIFICATIONS:

Inclusion
- Diagnosis of recurrent pericarditis

Exclusion
- Pericarditis secondary to specific prohibited etiologies, including tuberculosis (TB); neoplastic, purulent, or radiation etiologies
- Post-thoracic blunt trauma (e.g., motor vehicle accident)
- Myocarditis
- Systemic autoimmune diseases with exception of Still’s disease, pregnancy, hx HIV, prednisone > 60 mg/day, positive Hep B or C, serious infection

MHIF was first in the world to enroll in this trial and has 4 subjects enrolled out of the 9 in the world. Pericarditis patients are experiencing significant benefits and most often have no chest pain after starting this medication.
Multimodality Imaging for Valvular Heart Disease – In Whom, When and Why

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Director, Cardiovascular Imaging Research Core Lab
Minneapolis Heart Institute
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Disclosures:
- Invest. Initiated Research Grant (Medtronic)
- Consulting (Circle, Siemens, Medtronic, Abbott, Mitralign, 4Tech)
- Research Support (Circle CV Imaging, Siemens, Abbott, Ziosoft, TomTec Inc.)
- Imaging Core Lab (Mitralign, 4Tech)
- Co-Investigator in Triluminate and Tendyne in MAC feasibility study (Abbott)
MDCT has been a game changer to improve TAVR procedural outcomes and patient selection

Current Management of Aortic Stenosis

- According to current guidelines AVR is indicated if:
  - Severe aortic stenosis (AVA ≤ 1.0 cm² and MGd ≥ 40mmHg) AND
  - Evidence of decompensation from adaptive hypertrophic response:
    - Development of symptoms (often subjective and difficult in the elderly with multiple comorbidities)
    - LV impairment (EF < 50%) (sometimes late and irreversible)

Nishimura et al. JACC 2014;63:e57-185

But in clinical practice... Lots of other questions:
- Would the extent of cardiac damage (beyond LV) predict outcomes, despite successful TAVR?
- Is LVEF ≥ 50% really normal in the setting of severe AS? Any role for global longitudinal strain?
Pathophysiology of right-heart involvement in AS
Backward pressure transmission


AS Staging Classification

- PARTNER 2 Trial patients who received either SAVR or TAVR
- Extent of cardiac damage by baseline echocardiogram prior to AV intervention
- Outcomes:
  - All-Cause Death and
  - Cardiac Death

• Large single-center, integrated health-care system, real-world validation of TAVR-only patients.
• "Dose response" of AS staging and outcomes.
• Stage 3 patients (PHTN and TR) had higher post-TAVR readmission rates for both cardiac (HR, 1.84; 95%CI, 1.13-3.00; P = 0.01) and non-cardiac causes.
• AS staging may improve patient care, risk stratification, assessment of prognosis, and shared-decision making for patients undergoing TAVR.
• ANW MHI data is very similar to these results. (Liang, Sorajja)

![Image: Association of Structural and Functional Cardiac Changes With Transcatheter Aortic Valve Replacement Outcomes in Patients With Aortic Stenosis]

**Going Beyond Ejection Fraction...**
**a case for Myocardial Strain Imaging**

Pibarot, Dumesnil. JACC 2012;60:169–80
Myocardial Function in AS

Ng AC, Delgado V et al. Eur Heart J. 2011;32(12):1542-50

P < 0.001

Impaired Myocardial Deformation Might Be Of Prognostic Importance in Asymptomatic AS with Preserved LVEF>50%

Vollema et al. JAMA Cardiol. 2018 Sep 1;3(9):839-847.
Correlation between Global Longitudinal Strain and Left Ventricular Ejection Fraction

N=510 patients

Pearson correlation:
- \( r = -0.711 \)
- \( p < 0.001 \)

Chi-Square 41.19, \( p < 0.001 \)

Follow-up (months)

Cumulative Survival (%)

1. Normal LVEF/Preserved GLS (\( \geq -16.1\% \))
2. Normal LVEF/Reduced GLS (\( < -16.1\% \))
3. Impaired LVEF

All-cause mortality after TAVR according to GLS and LVEF

Chi-Square 20.61, \( p < 0.001 \)

Chi-Square 41.19, \( p < 0.001 \)

Follow-up (months)

Cumulative Survival (%)

1 vs. 2: \( p = 0.024 \)
1 vs. 3: \( p < 0.001 \)
2 vs. 3: \( p = 0.152 \)
Incremental prognostic value of GLS

Panel A - All patients

<table>
<thead>
<tr>
<th>Model $\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>STS</td>
<td>25.3</td>
</tr>
<tr>
<td>STS + LVEF</td>
<td>45.7</td>
</tr>
<tr>
<td>STS + GLS</td>
<td>35.0</td>
</tr>
</tbody>
</table>

Panel B - Patients with normal LVEF (≥ 55%)

<table>
<thead>
<tr>
<th>Model $\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>STS</td>
<td>20.1</td>
</tr>
<tr>
<td>STS + LVEF</td>
<td>45.7</td>
</tr>
<tr>
<td>STS + GLS</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Supplemental Figure 1. Kaplan-Meier analysis

Panel A – by EF 50% and GLS -16.1%

Chi-Square 19.68, p < 0.001

1 vs. 2 p = 0.008
1 vs. 3 p = 0.001
2 vs. 3 p = 0.15

Panel B – by EF 60% and GLS -16.1%

Chi-Square 13.54, p = 0.001

1 vs. 2 p = 0.004
1 vs. 3 p = 0.001
2 vs. 3 p = 0.54

Fukui M, ... Cavalcante JL. Presented at ACC 2019. Manuscript under peer review.
GLS analysis using 2D-CT Cardiac Performance Analysis prototype software

LVEF = 60%, GLS = -24.1%


MBIF CV Grand Rounds – April 22, 2019

Multicentric CMR Registry in severe AS prior to SAVR or TAVR (n=674)

- Scar was present in 51% (18% infarct pattern, 33% noninfarct).
  - Doubled all-cause mortality: (26.4% vs 12.9%; p<0.001) and
  - Tripled CV mortality (15% vs 4.8%; p<0.001)
  - Regardless of etiology (infarct or non)
  - Regardless of the intervention

- 1% increase scar burden
  - 10% increased all-cause mortality
  - 8% increased cardiovascular mortality


Clinical Risk Score to Predict LV Fibrosis (LGE) in Aortic Stenosis


C-statistic: 0.85

Asymptomatic Patients with Severe Aortic Stenosis
AV Vmax > 4.0 m/sec

Screening for Decompensation
Elevated hs-Troponin or ECG Strain

CMR
Mid-wall Fibrosis

RANDOMISATION (n=400)

EARLY SURGERY/TAVI (n=200)  STANDARD OF CARE (n=200)

3 Years Follow up
All cause mortality / Unplanned AS related hospital admission

REGISTRY
Impact of CMR-GLS and LGE on outcomes after AVR

- 95 patients receiving AVR (2/3 SAVR, 1/3 TAVR)
- FT-GLS was measured from all three long-axis views.
- 56% of patients had LGE (mostly non-infarct).
- + LGE doubled all-cause mortality.
- Important interaction between GLS x LGE.

Fukui M, ..., Cavalcante JL. SCMR 2019

Unveiling transthyretin cardiac amyloidosis and its predictors among elderly patients with severe aortic stenosis undergoing transcatheter aortic valve replacement

- N=151 patients with severe AS had Tc-PYP scan within 30-days after TAVR.
- Mean age = 84 ± 6 years
- 24/151 (16%) had + Tc-PYP scan consistent with ATTR-CA
  - Older (86 ± 6 vs. 83 ± 6 yrs, p=0.04)
  - Higher BNP (522 vs. 275, p=0.04)
  - Low-flow, low-gradient was 3.7x more common in these patients.
- Outcomes?

When to Suspect Cardiac Amyloidosis?

- Octogenarians with HFpEF, thick walls
- Male > Female
- Low-gradient aortic stenosis
- Atrial Fibrillation (high cardioembolic risk!)
- History of:
  - Carpal tunnel syndrome
  - Spinal stenosis
  - Biceps tendon rupture (Popeye’s sign)


Cardiac Amyloidosis is common and associated with worse outcomes

- 16% (1:6) of patients being evaluated for TAVR.
- All octogenarians, LFLG is very common. M > F.
- Median follow-up=18 months
- 40 deaths (35%) occurred.
- AS+CA had significantly higher 1-year all-cause mortality (56% vs. 20%, p<0.001)
- High HR=2.84 despite multivariate analysis.

1st Part - Conclusions

- In the context of AS/TAVR CMR can provide important contributions:
  - AS is a disease of the valve, vessels and the myocardium.
  - Watching for LVEF is not enough. GLS is upstream and allows for identification of subclinical myocardial dysfunction.
  - Myocardial fibrosis doubles the mortality whether patients get SAVR or TAVR. Should we intervene prior to its development?
  - Cardiac amyloidosis is common and appears to be associated with worse outcomes. Pre-TAVR screening?

Outline

Risk Profiling in Aortic Stenosis | Growing Role of MMI in MR
---|---
The Dark Side of the Moon - Forgotten Valve? | Observations and Future Directions
MR Staging and Outcomes

<table>
<thead>
<tr>
<th>Stages/Criteria</th>
<th>Stage 0</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Cardiac Damage</td>
<td>LA Damage</td>
<td>LV Damage</td>
<td>Pulmonary Vasculature and/or Tricuspid Damage</td>
<td>RV Damage</td>
</tr>
<tr>
<td>Echocardiogram</td>
<td>Indexed left atrial volume &gt; 34 ml/m²</td>
<td>LVEF &lt; 60%</td>
<td>Pulmonary hypertension (PASP ≥ 60 mmHg)</td>
<td>&gt; Mild RV dysfunction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Atrial Fibrillation</td>
<td>LV Dilatation</td>
<td>&gt; Moderate tricuspid regurgitation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Niikura H et al. Unpublished data

- 696 patients (69% MV Surgery; 31% TMVR - MitraClip)
- Echo classification based on baseline TTE

Niikura H et al. Unpublished data
Baseline GLS independently associated with outcomes in MitraClip patients (N=155)

Unadjusted

Adjusted for STS-PROM score, AFib and PASP

Mean age 83±7 years, 52% men, mean LVEF 56±10%

Fukui et al. Unpublished data

CMR Evaluates Different Types and Etiologies of Mitral Regurgitation

Primary

Secondary

P2 Flail

DCM

Ischemic CMP
When to consider CMR in Mitral Regurgitation?

- Symptoms ≠ visualized MR
- Is there severe MR?
- Scar Burden and Location

How do we quantify mitral regurgitation with CMR?

- What is the LV stroke volume?
- What is the forward flow?

- Mitral Regurgitant Volume (MR Vol):
  \[ \text{Mitral Regurgitant Volume} = \text{LV SV} - \text{Aortic forward flow} \]

- Mitral Regurgitant Fraction (%):
  \[ \frac{\text{MR vol}}{\text{LV SV}} \]
Quantification of LV/RV EF, volumes, SV and mass

No need for contrast

Quantification of LV Forward Flow
2D Phase Contrast
Mitral Regurgitant Volume (MR Vol):
= LV SV - Aortic forward flow

Mitral Regurgitant Fraction (%):

\[
\text{MR Fraction} = \frac{\text{MR vol}}{\text{LV SV}}
\]

MR Volume = 86 - 46 = 40 ml/beat
MR Fraction = 40/86 = 46%

Specific MR cutoffs for Cardiac MRI do not exist

Table 6: Grading the severity of chronic MR by echocardiography

<table>
<thead>
<tr>
<th>Quantitative†,‡</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>EROA, 2D PISA (cm²)</td>
<td>&lt;0.20</td>
<td>0.20-0.39</td>
<td>0.30-0.39 (may be lower in secondary MR with elliptical ROA)</td>
</tr>
<tr>
<td>Tilt (mL)</td>
<td>&lt;30</td>
<td>30-44</td>
<td>45-55†</td>
</tr>
<tr>
<td>RF (%)</td>
<td>&lt;20</td>
<td>20-35</td>
<td>40-49</td>
</tr>
</tbody>
</table>

- Poor TTE quality or low confidence in measured Doppler parameters
- Discordant quantitative and qualitative parameters and/or clinical data

Indeterminate MR
Consider further testing: TEE or CMR for quantification

* Beware of underestimation of MR severity in eccentric, wall-impinging jets; quantification is advised

** All values for LUSCA by PISA assume holosystolic MR; single frame LUSCA by PISA and VCA overestimate non-holosystolic MR

Regurgitant volume for severe MR may be lower in low flow conditions.

Zoghbi et al. JASE 2017; 30(4):303-371
CMR predicts MR severity and reverse remodeling better than TTE

26/38 had f/u CMR after MV surgery

N=103 patients with primary MR

Uretsky S et al. 2015;65(11):1078-88

CMR quantification of MR is superior to TTE in predicting outcomes

- 25% of disagreement
- Mitral Reg. Vol: Echo >> CMR
- Patients with late systolic, eccentric or multiple jets showed moderate agreement (k=0.53, 95%CI 0.41-0.64)


CMR Reg. Volume ≥ 50 mL defined Severe 1st MR

N=258 asymptomatic pts with ≥ moderate organic MR

Mean f/u of 5 years
56yo male with near-syncope and sustained VT. Normal coronary CTA. TTE shows MVP and moderate MR.

There is MVP... and MVP...

Abstract. Floppy mitral valve is usually attributed to connective-tissue degeneration. However, we have observed several instances in which a floppy mitral valve and an abnormal mitral annulus fibrosus were present at autopsy. To study this association, we examined 600 hearts (after postmortem arteriography and fixation in formalin) from autopsies of adults at the Johns Hopkins Hospital. Twenty-five (5 percent) of the hearts had a morphologically typical floppy mitral valve; in 23 of them (92 percent), the mitral annulus fibrosus showed disjunction — i.e., a separation between the atrial wall-mitral valve junction and the left ventricular attachment. In 42 other hearts (5 percent), which were from significantly younger patients (mean age ± SE, 60 ± 2 years vs. 60 ± 5; P < 0.05), there was mitral annulus disjunction but no floppy mitral valve. Two hearts had a floppy mitral valve but no disjunction of the annulus; both of them had old infarcts of the papillary muscle. Our results show that floppy mitral valve is significantly associated with disjunction of the mitral annulus fibrosus (P < 0.001).

We suggest that floppy mitral valve develops from hypomobility of the valve apparatus, and that it is usually secondary to disjunction of the mitral annulus fibrosus, an anatomic variant in the morphology of the annulus. (N Engl J Med 1986; 314:535-40.)
• Pathology registry 650 autopsy young (≤ 40 yrs) with sudden cardiac death (SCD)
• 43 Cases with MVP identified (7% of all SCD, 13% of women)
• Bileaflet involvement in 70%
• PM fibrosis in 100% and inferobasal in 88%


Prevalence of myocardial fibrosis is higher in MVP vs. non-MVP patients. MF increases with greater LV remodeling and MR severity.

Kitikungvan D et al. JACC 2018 Aug 21;72(8):823-834

CMR for Secondary MR

The Case for Ischemic MR
02 RCTs using MitraClip device had completely different results

MITRA FR (N=304)

- 63% of patients had Ischemic CMP

COAPT (N=614)

- 61% of patients had Ischemic CMP


Why are the COAPT Results so Different from MITRA-FR?
Possible Reasons

<table>
<thead>
<tr>
<th></th>
<th>MITRA-FR (n=304)</th>
<th>COAPT (n=614)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe MR entry criteria</td>
<td>Severe FMR by EU guidelines: EROA &gt;20 mm² or RV &gt;30 mL/beat</td>
<td>Severe FMR by US guidelines: EROA &gt;30 mm² or RV &gt;45 mL/beat</td>
</tr>
<tr>
<td>EROA (mean ± SD)</td>
<td>31 ± 10 mm²</td>
<td>41 ± 15 mm²</td>
</tr>
<tr>
<td>LVEDV (mean ± SD)</td>
<td>135 ± 35 mL/m²</td>
<td>101 ± 34 mL/m²</td>
</tr>
<tr>
<td>GDMT at baseline and FU</td>
<td>Receiving HF meds at baseline – allowed variable adjustment in each group during follow-up per “real-world” practice</td>
<td>CEC confirmed pts were failing maximally-tolerated GDMT at baseline – few major changes during follow-up</td>
</tr>
<tr>
<td>Acute results: No clip / ≥3+ MR</td>
<td>9% / 9%</td>
<td>5% / 5%</td>
</tr>
<tr>
<td>Procedural complications*</td>
<td>14.6%</td>
<td>8.5%</td>
</tr>
<tr>
<td>12-mo MitraClip ≥3+ MR</td>
<td>17%</td>
<td>5%</td>
</tr>
</tbody>
</table>

*MITRA-FR defn: device implant failure, transf or vasc comp/ml surg, ASD / card shock, cardiac embo/embolite, tamponade, urg card surg

(Slide courtesy of Dr Gregg Stone, TCT 2018)
In secondary ischemic MR, the problem is not the valve but in the LV...

![Graph showing LV Remodeling, IMR Severity, and Myocardial infarct size (MIS)]

In the subgroup of patients who received CABG+MV surgery (n=121), there was a **survival benefit** for patients with significant ischemic MR (reg. fraction ≥ 35% and low scar, < 15%).

Cavalcante JL, Kwon DH. In review
Program in valve size and bracket position:
Measure neo-LVOT (very minimum 1.5 cm$^2$ and desirable > 2.0 cm$^2$)

- 0 mm atrialized, no neo-LVOT
- 6 mm atrIALIZED, 0.6 cm$^2$ neo-LVOT
- 8 mm atrialized, 1.6 cm$^2$ neo-LVOT

CTA in follow-up for Tendyne (apical anchor):
Neo-LVOT with valve in place (similar to projection)
Tendyne Feasibility/CE Mark Study

Summary of First 100 Patients Treated

- High implant success rate (97%)
- No operative deaths, no CV surgery
  - 6% mortality at 30-day (STS-PROM = 7.9%)
  - 1.3% stroke
- Sustained MR reduction with 98% no MR at 1 year
- Significant symptomatic improvement at 1-yr
  - 88% of survivors in NYHA Class I/II
  - +7.5 point mean improvement in KCCQ

Sorajja et al. JACC 2019 Mar 26;73(11):1250-1260  Slide courtesy of Paul Sorajja
Pre-TMVR

1 month Post-TMVR

Transseptal TMVR platform
TMVR in MAC

Guerrero M et al. JACC 2018 May 1;71(17):1841-1853

TABLE 6 Outcomes Relative to Experience

<table>
<thead>
<tr>
<th></th>
<th>First Half (n = 38)</th>
<th>Second Half (n = 56)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical success</td>
<td>41 (86.8)</td>
<td>48 (85.7)</td>
<td>0.12</td>
</tr>
<tr>
<td>30-day mortality</td>
<td>18 (31.0)</td>
<td>11 (19.0)</td>
<td>0.07</td>
</tr>
<tr>
<td>Complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve embolization</td>
<td>4 (7.3)</td>
<td>1 (1.8)</td>
<td>0.11</td>
</tr>
<tr>
<td>LVOT obstruction</td>
<td>6 (12.8)</td>
<td>7 (13.2)</td>
<td>0.47</td>
</tr>
<tr>
<td>Need for second valve</td>
<td>11 (19.0)</td>
<td>6 (10.3)</td>
<td>0.09</td>
</tr>
<tr>
<td>Cardiac perforation</td>
<td>2 (0.6)</td>
<td>0 (0)</td>
<td>0.17</td>
</tr>
<tr>
<td>Conversion to surgery</td>
<td>2 (7.1)</td>
<td>0 (0)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Values are n (%). *Cochran-Armitage trend test.
LVOT = left ventricular outflow tract obstruction.
Tendyne for Severe MAC
First-in-human Experience

8 patients treated
6 US, 1 France, 1 Germany
STS-PROM = 8.2±3.8%
MAC volume = 4,468 mm³
All with MAC invasion into myocardium
No 30-day deaths
No residual MR
One late death
6 alive >1 year and class I/II

Full results will be presented (Dr Gössl) in May/19 at EuroPCR

2nd Part - Conclusions

- In the context of MV disease, CMR has a growing complementary to echocardiography given reproducible quantification and evaluation of LV remodeling and regurgitation.
- Consider CMR whenever in question of MR severity.
- Emerging role of myocardial fibrosis as an important driver of outcomes for patients with Mitral Regurgitation.
- Dedicated software is required to assess the MV anatomy and suitability for TMVR (ViV, Valve in MAC, Native)
Outline

Risk Profiling in Aortic Stenosis

Growing Role of MMI in MR

The Dark Side of the Moon - Forgotten Valve?

Observations and Future Directions

Guidelines Absence

- L-sided valve surgery, severe TR (I)
- L-sided valve surgery, annular dilatation or RHF (IIA)
- Primary TR refractory to med rx (IIA)
- L-sided valve surgery with mod TR and PH (IIB)
- Severe TR and progressive RV enlargement (IIB)

No Class I indications for isolated TR

Slide courtesy of Paul Sorajja
ASE Guidelines emphasize multiparametric approach
But in reality → color Doppler mapping and jet area

But it shouldn’t be so hard...

Trace/Mild

Moderate

Massive/Torrential

Additional Views with Color Doppler Mapping

Unable to define flow convergence zone for PISA calculation
Spectral Doppler of TR jet

Putting it together...

Grading the Severity of Chronic TR by Echocardiography

<table>
<thead>
<tr>
<th>TR Severity</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV morphology</td>
<td>Normal or mildly abnormal leaflets</td>
<td>Moderately abnormal leaflets</td>
<td>Severe valve lesions (e.g., Hall lesions, severe retraction, large perforation)</td>
</tr>
<tr>
<td>RV and RA size</td>
<td>Usually normal</td>
<td>Normal or mild dilation</td>
<td>Usually dilated</td>
</tr>
<tr>
<td>Inferior vena cava waveform</td>
<td>Normal or diastolic 2:1 or more</td>
<td>Diastolic &lt;2:1 form</td>
<td></td>
</tr>
<tr>
<td><strong>Color Flow jet area</strong></td>
<td>Small, narrow, control</td>
<td>Moderate control</td>
<td>Large central jet or eccentric wall-perforating jet of variable size</td>
</tr>
<tr>
<td><strong>Flow convergence zone</strong></td>
<td>Not visible, transient or small</td>
<td>Intermediate in size and duration</td>
<td>Large throughout systole</td>
</tr>
<tr>
<td><strong>Color Flow jet</strong></td>
<td>Parasternal/Costal</td>
<td>Diastolic, parasternal or triangular</td>
<td>Diastolic, other triangular</td>
</tr>
</tbody>
</table>

**Notes:**
- Mild-Moderate or Severe TR?
- Mild-Moderate or Severe TR?

Same patient, same day, different probes... (3D TTE)

New Proposed Grading Scheme tries to improve consistency but it’s a work in progress...

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Massive</th>
<th>Torrential</th>
</tr>
</thead>
</table>
| VC (aplanar)  
(EROA (PSA))             | <3 mm    | 3-6.9 mm | 7-13 mm| 14-20 mm| ≥21 mm     |
| 3D VCA or quantitative EROA* | <20 mm$^3$ | 20-39 mm$^3$ | 40-59 mm$^3$ | 60-79 mm$^3$ | ≥80 mm$^3$ |
|                           | 75-94 mm$^3$ | 95-114 mm$^3$ | ≥115 mm$^3$ |

VC, vena contracta; EROA, effective regurgitant orifice area; 3D VCA, three-dimensional vena contracta area.

*3D VCA and quantitative Doppler EROA cutoffs may be larger than PSA EROA.

• Need to integrate the severity of RV function and remodeling

A Natural History Construct for TR

RA dilation → Tricuspid annulus dilation occurs → AFIB

Survival and Sx

Moderate

Severe

Years of indolence

Massive

Torrential

Very steep both ways

Years

Impairment already

Functional CTA for Quantification of right-sided function and Remodeling

RV 4ch View

RV 2ch View

RV 3ch View

Adapted from slide courtesy of Paul Sorajja
RV “centric” SAX Reconstruction allow for quantification of RA, RV volumes and EF

Anatomical ROA – Average Systolic Frames

Average Anatomical ROA=0.629 cm²
RV Longitudinal Strain

- RV 4ch View
  - RV GLS (6 segments)
  - \(-19.5\%\)

- RV 2ch View
  - RV GLS (6 segments)
  - \(-18.3\%\)

Endoluminal 3D Views

- Leaflet Motion
- Visualization of the valve gap
  - Evaluation of TR severity
  - Individualization of therapy
- Best angles for leaflet grasping and coplanar alignment for commissures
Patient with prior large inferior MI with RV infarct. Tethering of the posterior leaflet

CTA for Fluoroscopy Angle Planning
Importing CT for tricuspid leaflet segmentation and angles for fluoro overlay

Total Procedural Time: 50 mins
Global Illumination recons provide a photorealistic view of the anatomy and physiology of the TV and RV.

In collaboration with Vital Images/Cannon.

Role of CMR for RV and TR.

Circ Cardiovasc Imaging. 2017

Multi-modality Imaging for Assessment of Tricuspid Regurgitation Severity

Catheter-Based Therapies
Valve Leaflet Membrane
Polypoid Lesions
Non-Valvular Causes
Color Doppler Echocardiography (DVD) and MRI
Effective Regurgitant orifice area

Regurgitant Volume
Cardiac Magnetic Resonance
Right heart Catheterization
Transesophageal Echocardiography
Right heart volume and function
Correlation with assessment

Quantification of RV EF, volumes, RV SV
Does not require contrast

HOW TO QUANTIFY TR USING CARDIAC MRI?
Quantification of RV Forward Flow
2D Phase Contrast (does not require IV contrast)

Tricuspid Regurgitant Volume (TR Vol):
= RV SV - Pulmonic forward flow
Tricuspid Regurgitant Fraction (%):
= TR vol / RV SV

TR Volume=101-46= 55 ml/beat
TR Fraction=55/101 = 54%
CMR Scanning of patients with Pacemaker and Defibrillator is feasible and safe

Quantification of RV and TR is feasible and does not require IV contrast

CMR Technology Continues to Evolve for patients with Afib and Heart Failure

Same patient, same scanner, different pulse sequence...
Superior and diagnostic image quality
Both RVEF and RVESVi are prognostically important prior to TV surgical intervention

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference</th>
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<tbody>
<tr>
<td>RVEF, %</td>
<td>Park JB et al. Radiology. 2016 Sep;280(3):723-34</td>
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<tr>
<td>RVESVi, %</td>
<td>Sanz J et al. JACC 2019 Apr 2;73(12):1463-1482</td>
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CMR w/ late-gadolinium enhancement imaging allows for tissue characterization of RV cardiomyopathy
3rd Topic - Tricuspid Regurgitation

- TR is not easy to quantify and depends on loading conditions which leads to inconsistency on the grading.
- TR is quite common but greatly undercalled. Low threshold for TEE or CMR. CTA 2nd best option.
- New grading scheme lacks validation but reflects the indolent course of this process where late presentation is often the case.
- Outcomes are dictated not by the severity of TR, but by the RV function and other comorbidities.
- CTA anatomical evaluation and quantification of RV volumes and RVEF is feasible and will represent an important opportunity to assess the effects of TV interventions.
Outline

- Risk Profiling in Aortic Stenosis
- Growing Role of MMI in MR
- The Dark Side of the Moon - Forgotten Valve?
- Observations and Future Directions

In closing, my observations of this place

“Creativity and passion are vital but tenacity marks the men and women who overcome skepticism and setbacks to implement their ideas.” Bob Hauser, MD
Our CMR Lab continues to grow!

- Optimization of scanning protocols - faster acquisition sequences, less breath hold, better patient experience
- Decrease in wait time for outpatients scans: (6 wks → 4 wks - goal: 2 wks)
- Rapid CMR protocols - 30-40 mins
- Adding 4th tech (1.0 FTE) and later shift - goal for 12 scans/day
- Partnership with EP service - Scanning of CIED (conditional or not)
- HeartIT structured reporting in May/19 → Queryable database.
- CMR Lab IAC accreditation - 2nd semester.
- Always looking for feedback!

Advanced Imaging Fellowship (CT/CMR)

- The continued volume growth and increasing complexity of cases seen at MHI is a testament of its commitment to innovate in healthcare care delivery, diagnostic and therapeutics.
- Large need for multimodality trained cardiologist.
- Currently it is non-ACGME accredited
- Goal: 01 position starting at July/2020 (1-year fellowship)
- Transitional Bridge Funding (3-5 years until ACGME accreditation):
  - ANW
  - Industry
  - Self-Funding (moonlighting, clinic)
Autopsy study:
- 22 normal hearts
- 20 hearts of MR patients w/ NYHA class II-III who died from extracardiac causes (bleeding, thromboembolism).
- 22 patients with MR and NYHA class III-IV, died early after MV replacement from cardiogenic shock/low output syndrome.

Circulation 1977;55:504-508
35 asymptomatic patients with moderate to severe MR.
No class I indication for MV surgery

Normal ECV = 23.7 ± 2%
Patient with Severe MR – LVEF=62%, ECV = 33%

Edwards NC et al.