
# Unravelling the complexity of multi-valve disease: understanding the haemodynamic interplay

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# Background

**Euro Heart Survey 2003:** multiple VHD (at least 2 moderate VHDs) observed in **20%** of the patients with native VHD and in **17%** of those undergoing intervention

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**Table 2** Concurrent combinations of valvular heart disease in Sweden between 2003 and 2010

| | AS | | AR | | MS | | MR | | PS | | PR | | TS | | TR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| AS | 36 319 | 100 | 2482 | 17.9 | 543 | 28.3 | 1849 | 9.9 | 54 | 2.2 | 13 | 2.0 | 37 | 12.3 | 206 | 7.1 |
| AR | 2482 | 6.8 | 13 853 | 100.0 | 117 | 6.1 | 1488 | 8.0 | 75 | 3.0 | 33 | 5.2 | 11 | 3.6 | 156 | 5.4 |
| MS | 543 | 1.5 | 117 | 0.8 | 1917 | 100.0 | 344 | 1.8 | 8 | 0.3 | 4 | 0.6 | 12 | 4.0 | 60 | 2.1 |
| MR | 1849 | 5.1 | 1488 | 10.7 | 344 | 17.9 | 18 595 | 100.0 | 47 | 1.9 | 33 | 5.2 | 38 | 12.6 | 830 | 28.8 |
| PS | 54 | 0.1 | 75 | 0.5 | 8 | 0.4 | 47 | 0.3 | 2460 | 100.0 | 180 | 28.3 | 30 | 9.9 | 14 | 0.5 |
| PR | 13 | 0.0 | 33 | 0.2 | 4 | 0.2 | 33 | 0.2 | 180 | 7.3 | 637 | 100.0 | 6 | 2.0 | 23 | 0.8 |
| TS | 37 | 0.1 | 11 | 0.1 | 12 | 0.6 | 38 | 0.2 | 30 | 1.2 | 6 | 0.9 | 302 | 100.0 | 35 | 1.2 |
| TR | 206 | 0.6 | 156 | 1.1 | 60 | 3.1 | 830 | 4.5 | 14 | 0.6 | 23 | 3.6 | 35 | 11.6 | 2885 | 100.0 |

Number of cases with different combinations of concurrent valvular heart disease diagnoses in 2003–2010 and proportion of cases with each valve disease (columns) that were concurrent with each of the other seven valve diseases (rows). AS, aortic stenosis; AR, aortic regurgitation; MS, mitral stenosis; MR, mitral regurgitation; PS, pulmonary stenosis; PR, pulmonary regurgitation; TS, tricuspid stenosis; TR, tricuspid regurgitation.

# MVD Pathophysiology is Complex: Points of Principle

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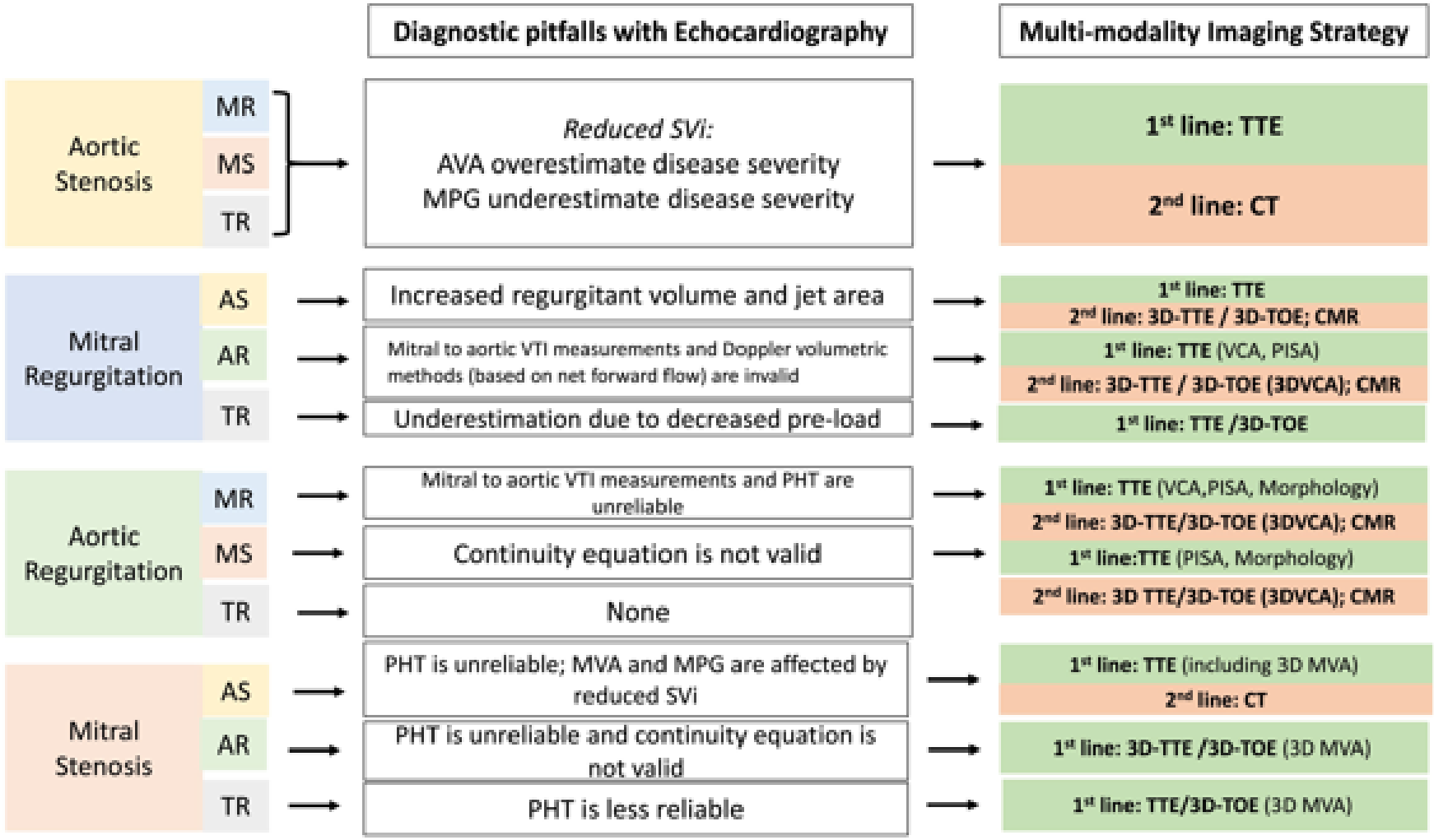
# Echo Pitfalls in MVD




*Donal et al: EACVI 2025*

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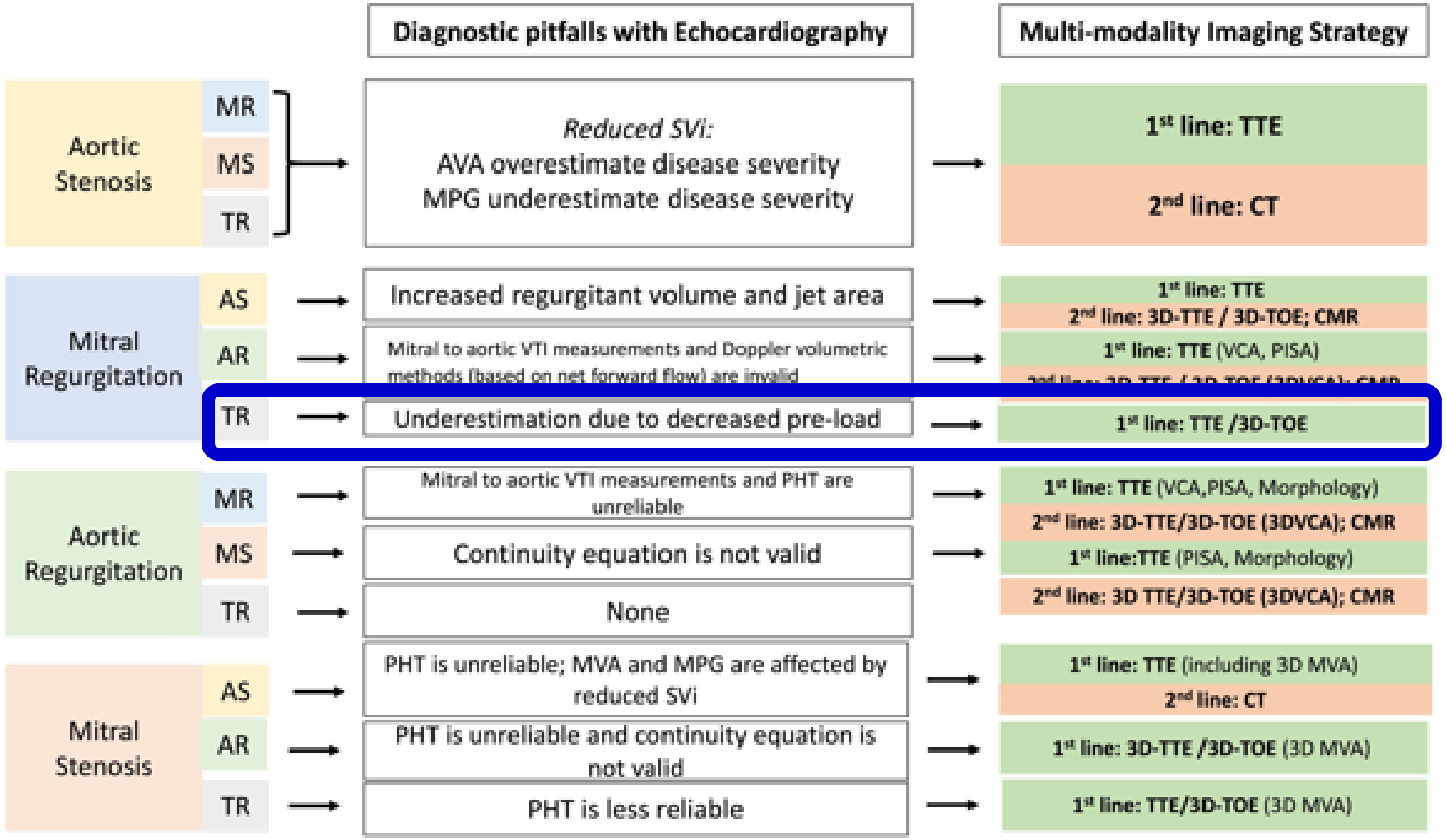



*Donal et al: EACVI 2025*


# Mitral Regurgitation and Tricuspid Regurgitation

# MR and TR Echo Assessment

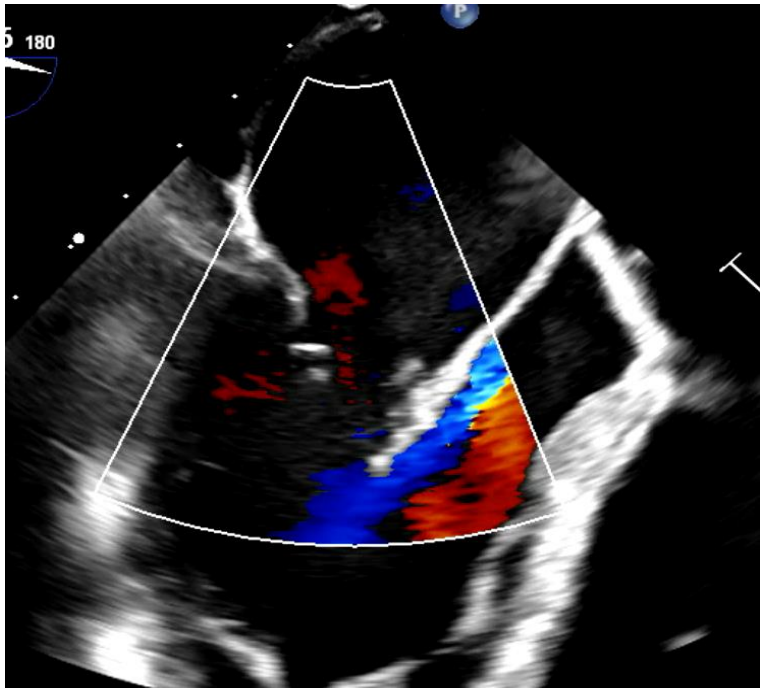
- Echo first-line imaging technique
- Assess MR and TR severity
- Assess MR and TR mechanism
- Quantify left and right heart size and chamber function
- Quantify pulmonary pressures
- **Most standard measures still applied reliably**

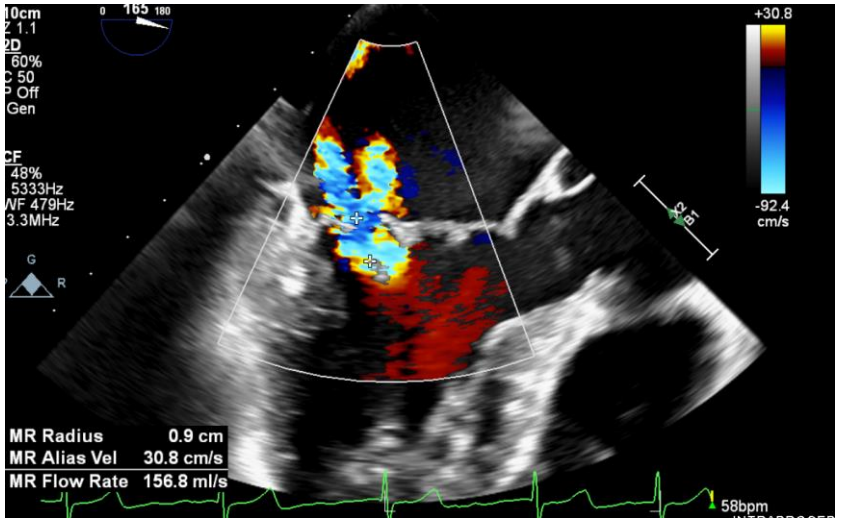
# MR and TR Echo Assessment

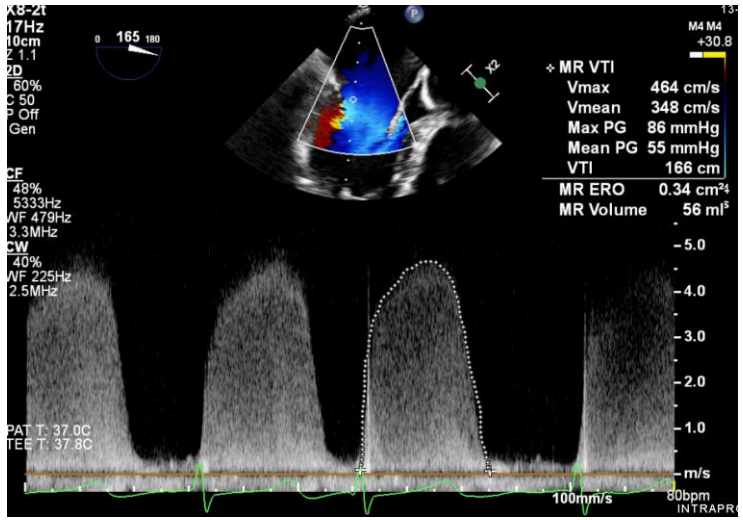
**Problems:**

1. Significant TR → reduces LV pre-load → **underestimates MR severity**

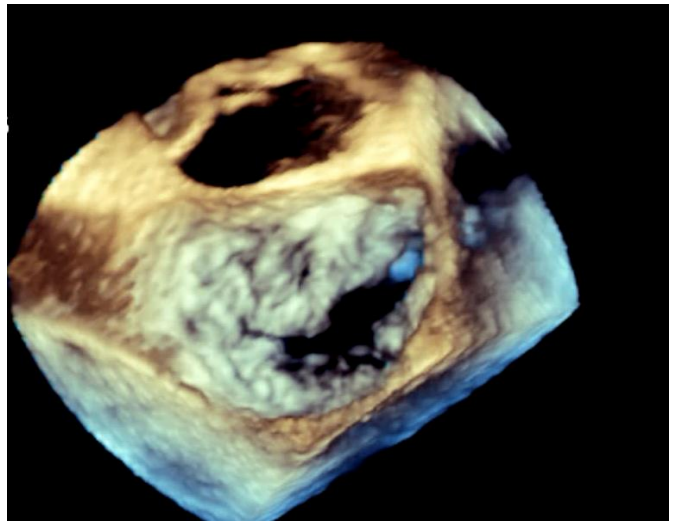
# 2D echo quantification of MR

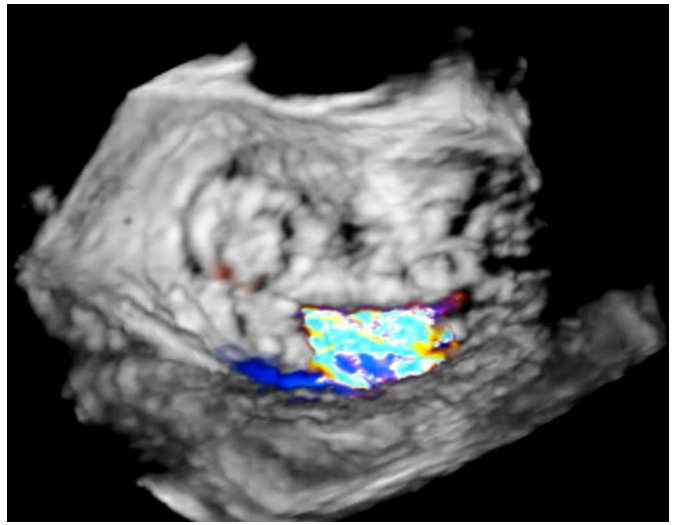


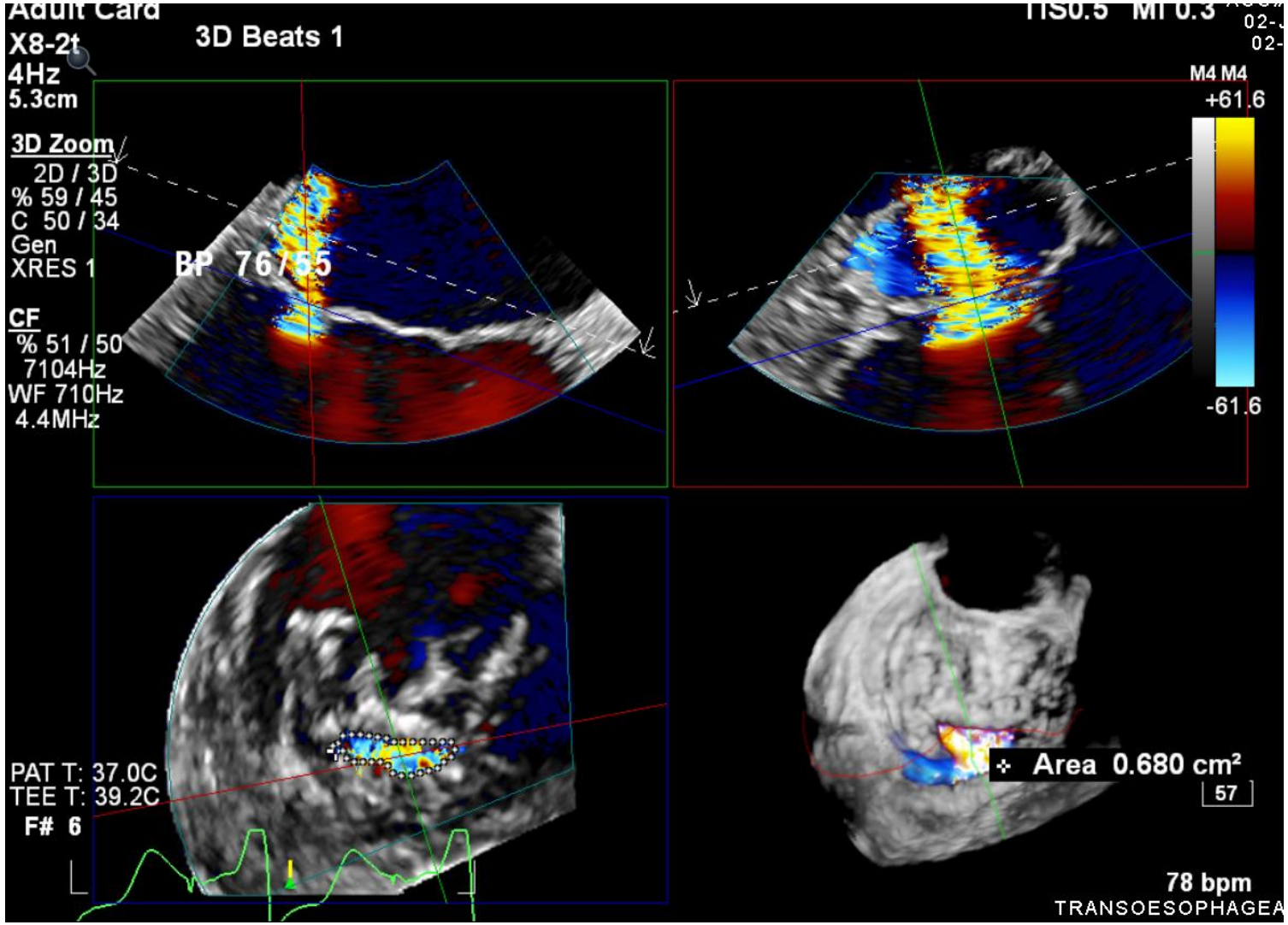


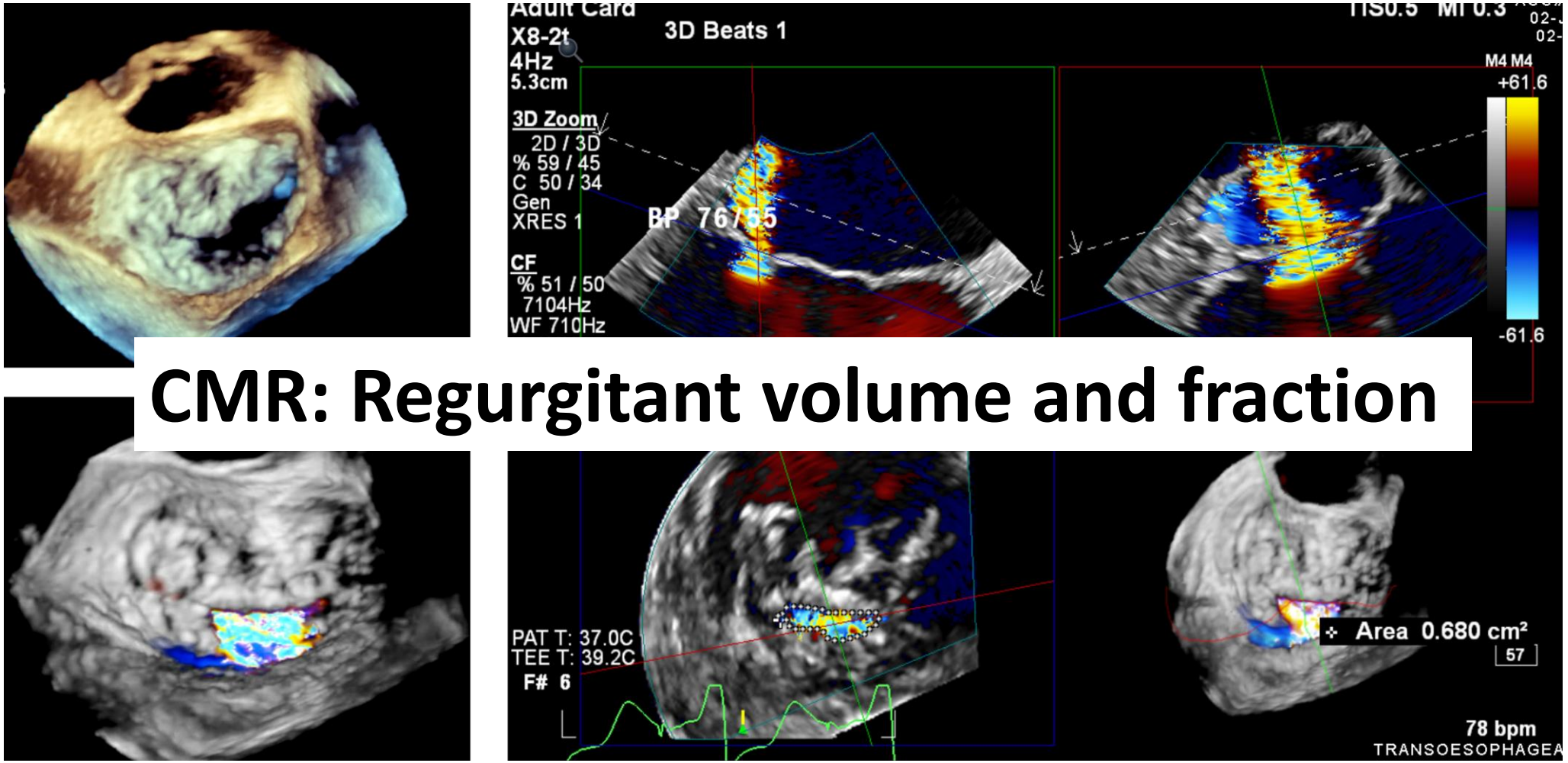
# Problem helped by measuring MR 3D VCA?







# Problem helped by CMR?




## CMR: Regurgitant volume and fraction

# MR and TR Echo Assessment

**Problems:**

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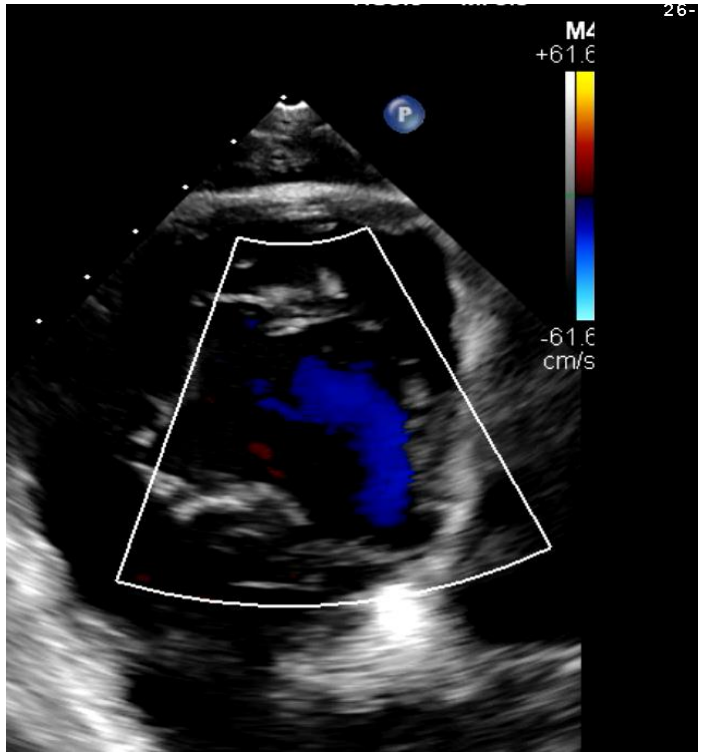
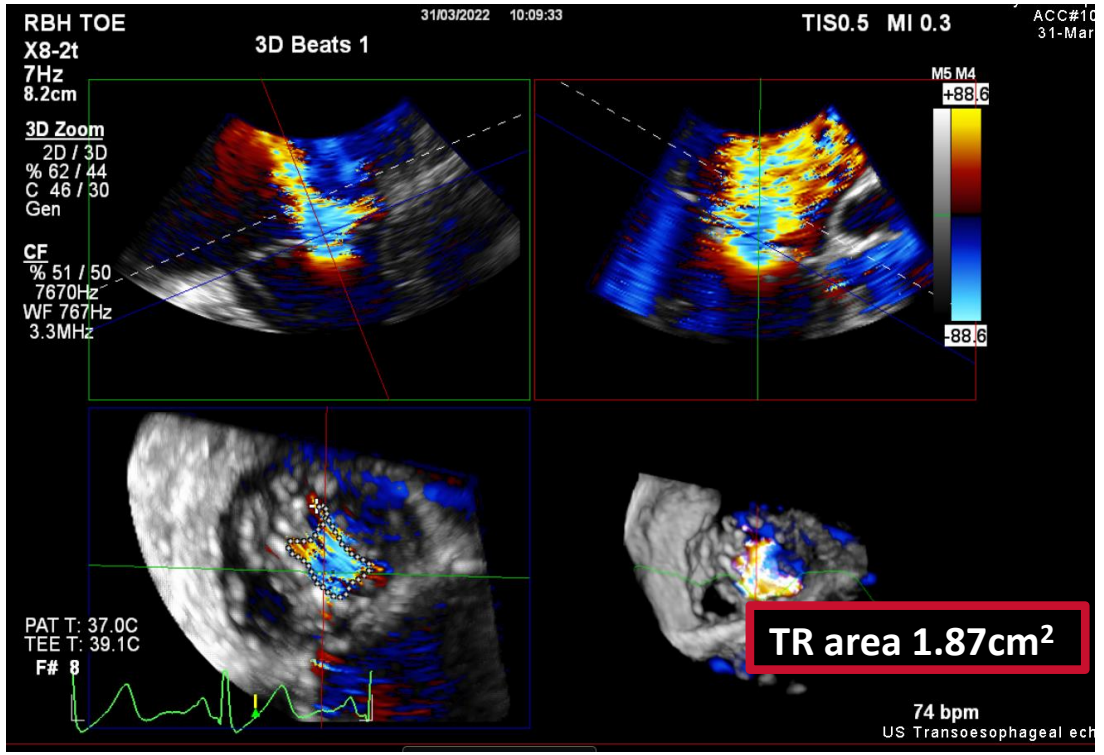
2. **TR severity** affected by changes in MR severity and PA pressure

# TR complicated by MR

- 3D echo (TTE and TOE) 3D VCA

  - non-circular shape in case of TR



# Pathophysiology of TR: Role of Aetiology

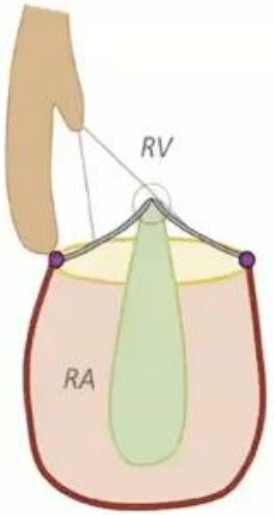
**Ventricular FTR (~ 70%)**
**Predominant leaflet tethering**

*Insufficient leaflet coaptation due to apical displacement*

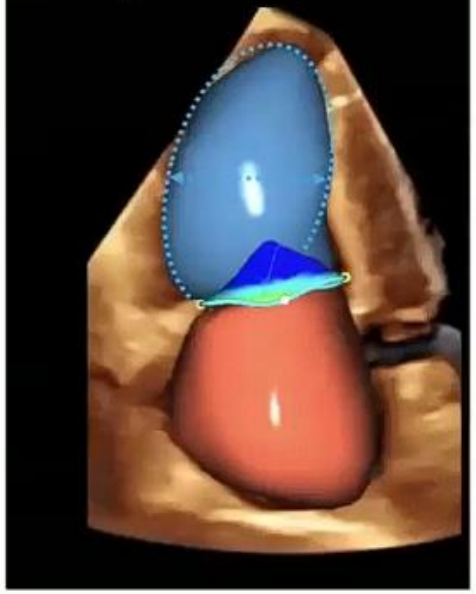
**Atrial FTR (~ 25%)**
**Predominant annular dilation**

*Insufficient leaflet coverage due to annular dilation*

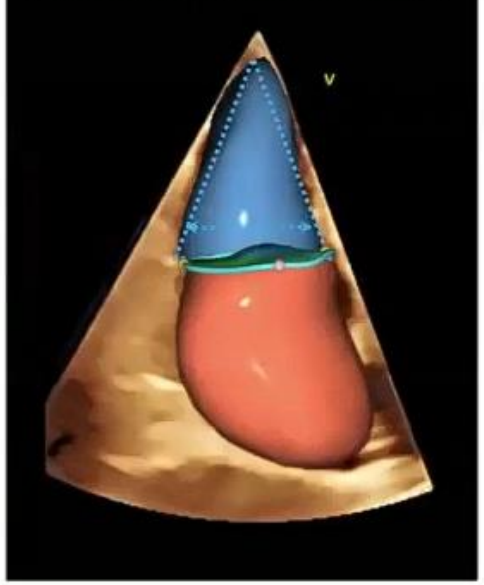
PH




End-systolic RA/RV ≤ 1



End-systolic RA/RV > 2



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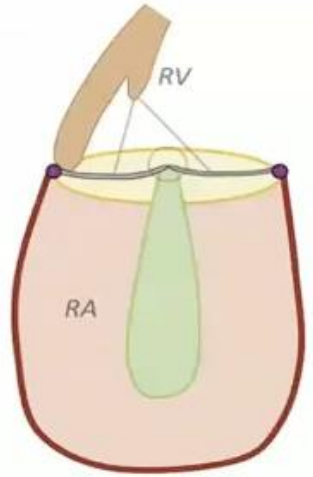
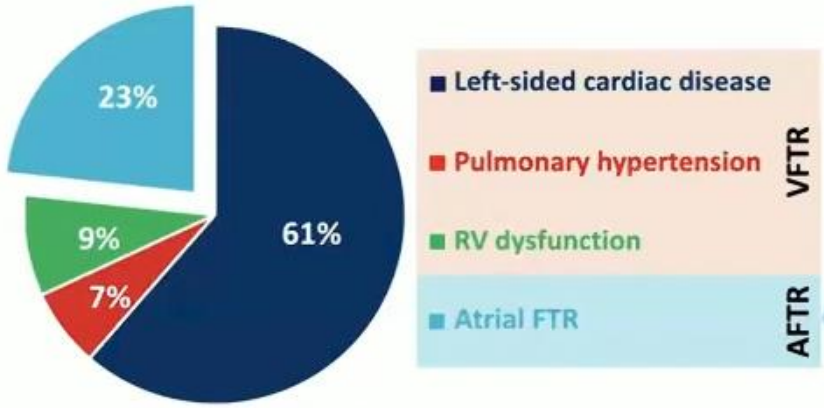


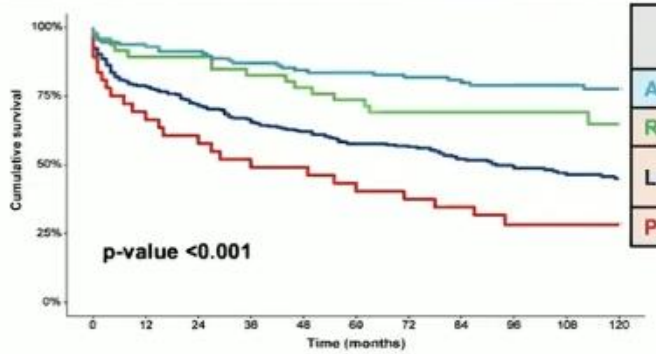

*Utsunomiya et al. EHJCVI 2020, Florescu et al. EHJCVI 2022, Muraru D et al. JASE 2021*

# Pathophysiology of TR: Importance of Aetiology

## Distribution of severe functional TR

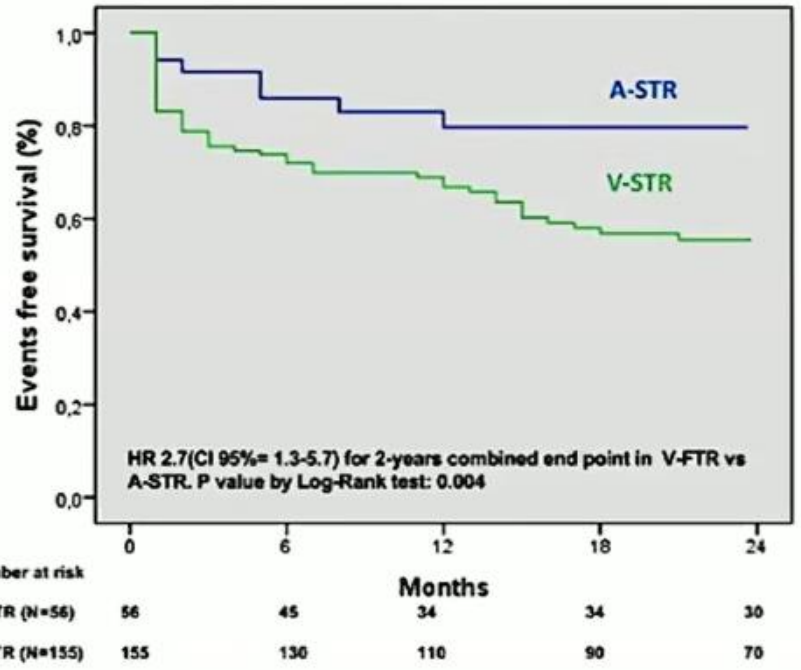



## Overall survival of severe functional TR




| | 1-year survival | 5-year survival | 10-year survival |
|---|---|---|---|
| Atrial FTR | 94% | 84% | 78% |
| RV dysfunction | 89% | 74% | 65% |
| Left-sided cardiac disease | 79% | 58% | 45% |
| Pulmonary hypertension | 69% | 43% | 28% |

**Combined end point of death for any cause and heart failure hospitalizations.**

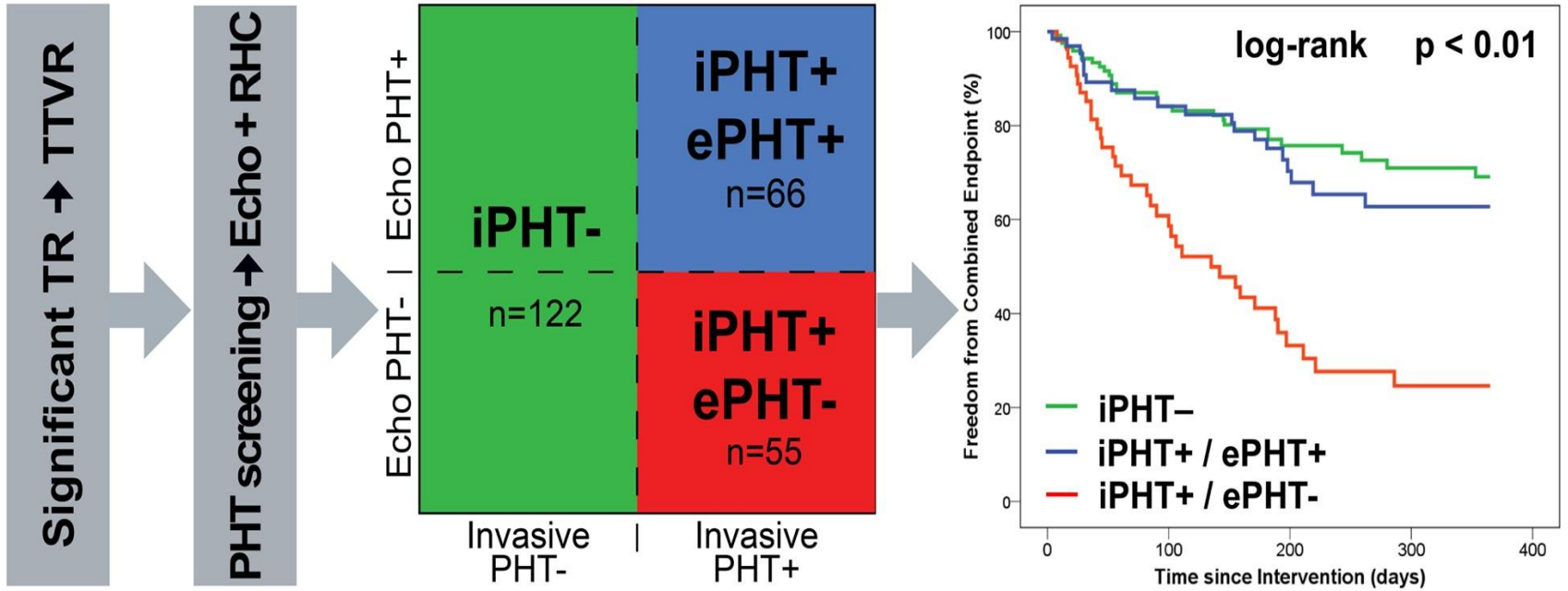



| Number at risk | | | | | |
|---|---|---|---|---|---|
| A-STR (N=56) | 56 | 45 | 34 | 34 | 30 |
| V-STR (N=155) | 155 | 130 | 110 | 90 | 70 |

*Gavazzoni M et al. Front Cardiovasc Med 2022*
*Gallo X et al. Eur Heart J Cardiovasc Imaging 2023*

# Discordant PHT

- reduced afterload-corrected TAPSE/SPAP during RHC and
- discordant PHT (>10 mmHg difference between non-invasive and invasive SPAP)
- independent predictors of worse outcomes (death, HF hospitalisation, and re-intervention) in severe TR




- discordant diagnosis of iPHT+/ePHT = highest risk for combined clinical endpoint [HR 3.76 (CI 2.25–6.37)]
- iPHT+/ePHT+ patients had a similar survival-free time from the combined endpoint compared to iPHT patients

*Lurz et al. EHJ 2020*


# Aortic Stenosis and Mitral Regurgitation

# Haemodynamic interactions that impact AS with MR

**Severe AS:**

Long-standing increased afterload

LVH and remodelling, dilatation, dysfunction of the LV

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Concomitant CAD in AS: association ischaemic MR

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LVH and remodelling, dilatation, dysfunction of the LV

Secondary MR due to leaflet tethering and mitral annular dilatation

Concomitant CAD in AS: association ischaemic MR

**Increased afterload due to AS:**

↑ trans MV systolic pressure gradient

↑ MR volume for any given MV ERO

# Problem with quantifying AS combined with MR:

**Significant MR**

↓ forward flow across aortic valve

MR-induced low-flow state reduces ↓ transaortic pressure gradient

# Problem with quantifying AS combined with MR:

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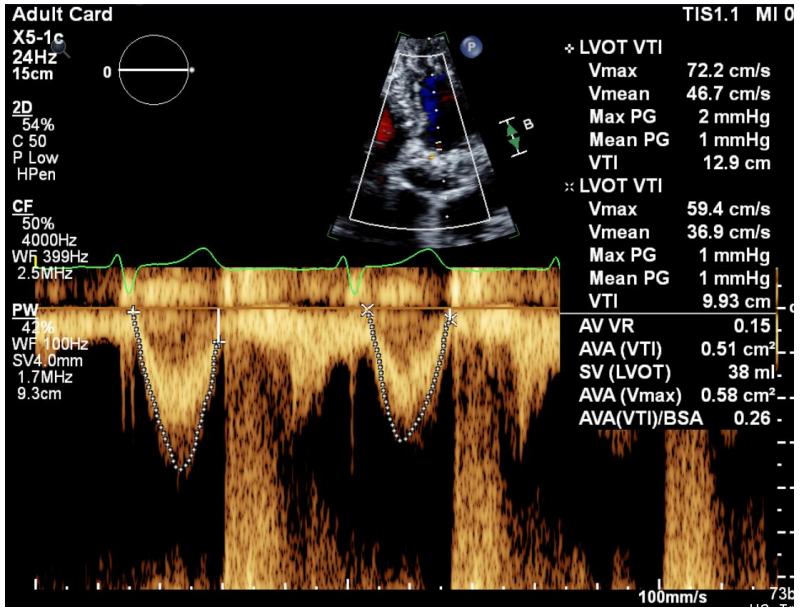
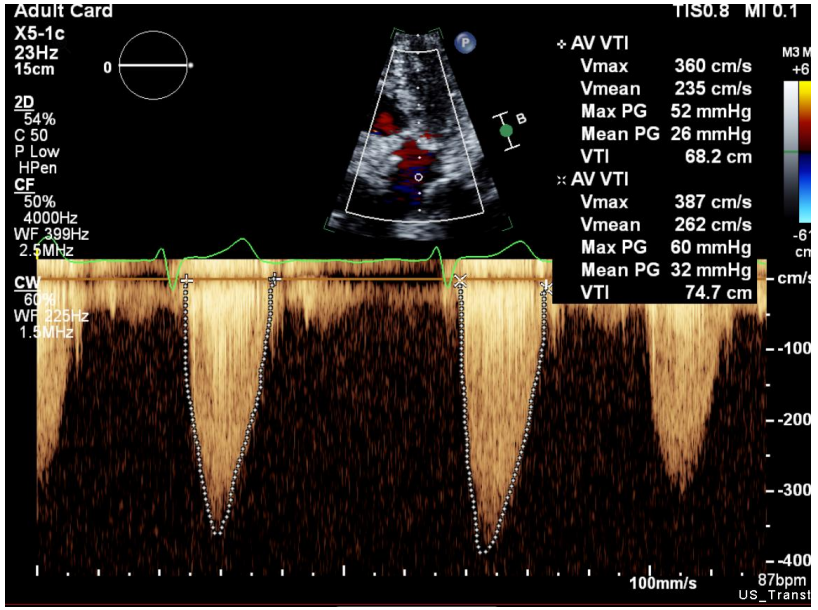
MR-induced low-flow state reduces ↓ transaortic pressure gradient (LF-LG AS)

1. low-flow, low-gradient AS frequent




# Problem with quantifying AS combined with MR:

Significant MR ↓ forward flow across aortic valve

MR-induced low-flow state reduces ↓ transaortic pressure gradient (LF-LG AS)

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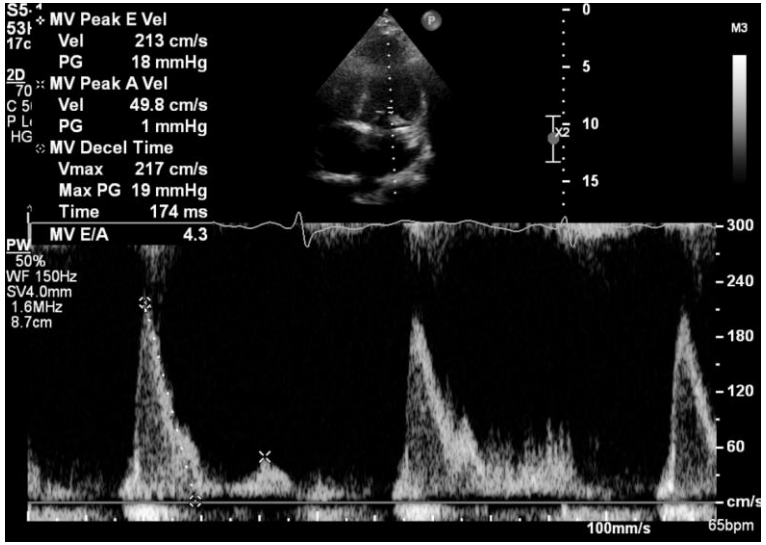


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5. DSE may fail to induce significant increase in LV outflow with severe MR

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- Prognostic tools recommended for single VHD not substantially validated in MVD
- Accepted cut-off values may not be applicable
- Management, timing, type (TCV vs Sx) of associated lesions <severe challenging

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- **Multi-modality imaging useful**
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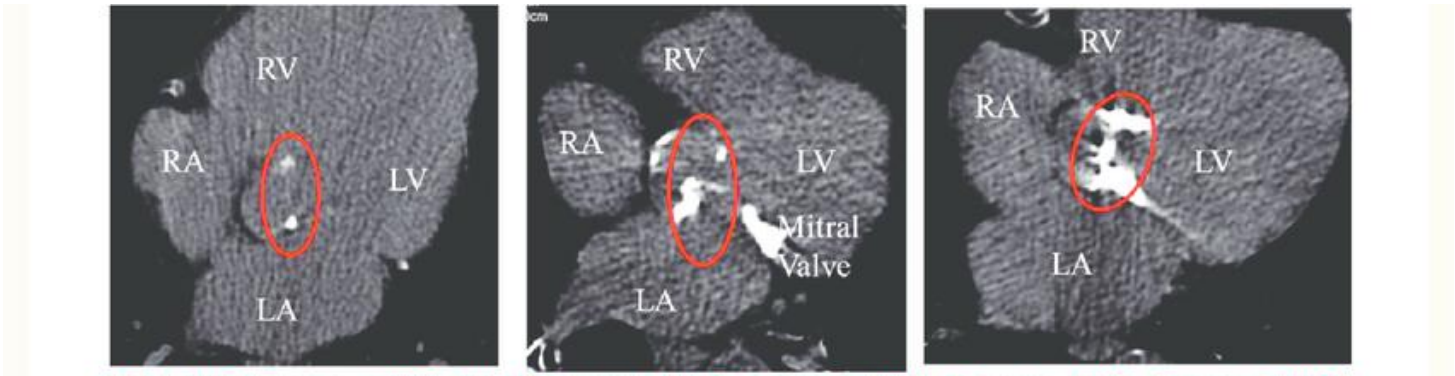
- **Multi-modality imaging useful**
- Load-independent measures such as valve planimetry (TOE, MSCT, MRI)
- AoV calcium score by MSCT (>2000AU men, >1200AU women)




Mild AVC. Score = 200 AU Moderate AVC. score = 800 Severe AVC. Score = 2000

# Multivalvular disease: ESC / EACTS Guidelines

- lack of data on combined or multiple-valve disease
- no evidence-based recommendations
- besides separate assessment of each valve lesion
  **“consider interaction between the different valve lesions”**
- AHA/ACC ESC/EACTS recommend managing according to **‘predominant lesion’**

# Multivalvular disease: ESC / EACTS Guidelines


Difficult - haemodynamic interactions may invalidate isolated stenosis/regurgitation

Use complementary multimodality in diagnostic uncertainties


# Unravelling the complexity of multi-valve disease: understanding the haemodynamic interplay

## Thank you very much for your kind attention