Objectives

- Considerations in management of multivalvular disease
  - Net clinical effect of multiple valvular lesions
  - Challenges in grading severity of each lesion by echocardiography
  - Treatment strategies
- Case Discussions

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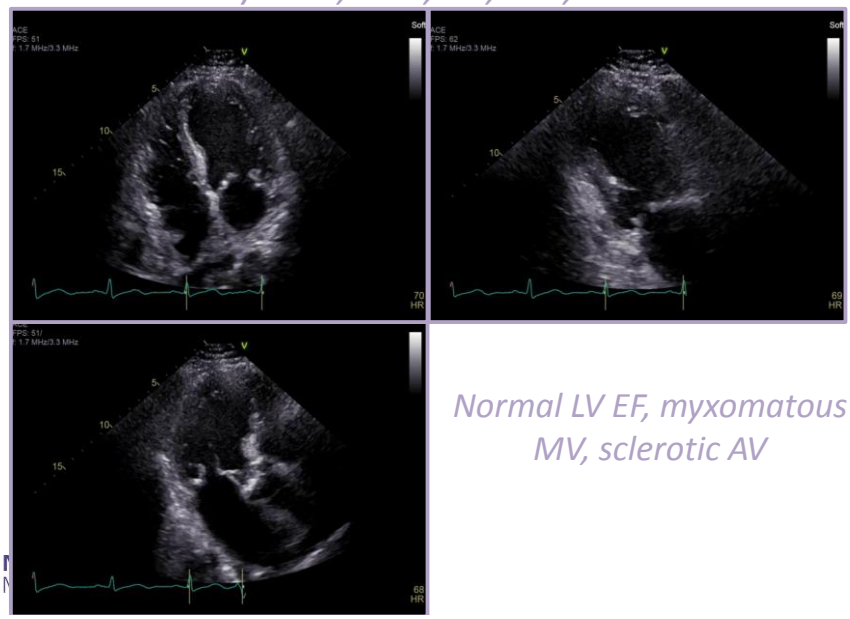
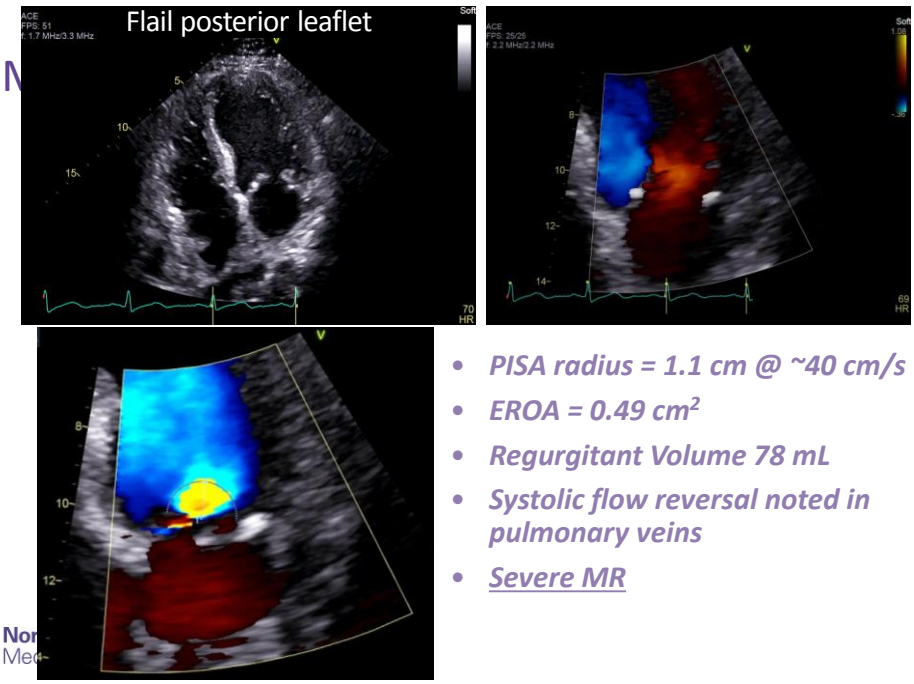
Case 1: AS + MR

91M in CHF w/ CAD, CKD, AS, MR,& AF-RVR

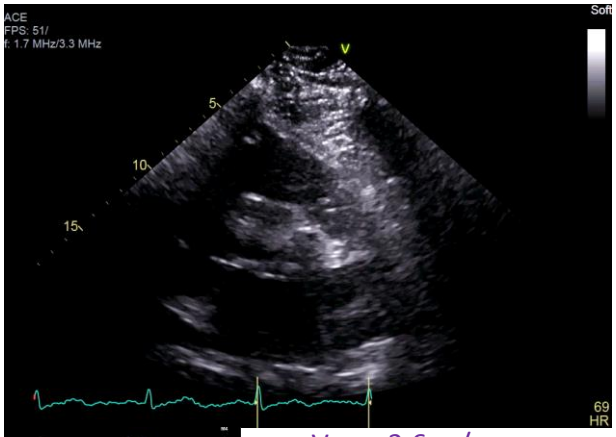


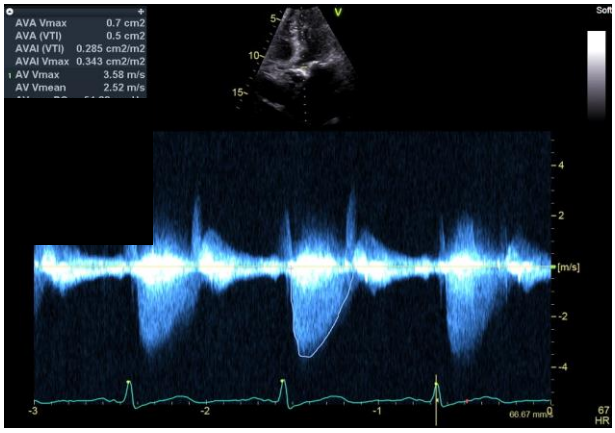
Normal LV EF, myxomatous MV, sclerotic AV

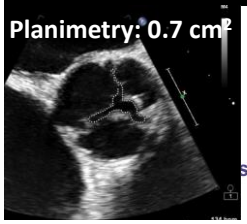


- ***PISA radius = 1.1 cm @ ~40 cm/s***
- ***EROA = 0.49 cm^2***
- ***Regurgitant Volume 78 mL***
- ***Systolic flow reversal noted in pulmonary veins***
- ***Severe MR***

AS







- Vmax 3.6 m/s
- Mean grad 29 mmHg
- AVA = 0.6 cm^2
- DI = 0.17
- SVI = 28 mL/m^2

} **Paradoxical low-flow/low-gradient AS**

Incidence and Etiology of Multivalvular Disease

- EuroHeart Survey: 14.6% of patients undergoing valve surgery
- STS Database: 10.9% of 623,039 patients undergoing valve surgery
  - 57.8%: Aortic + Mitral Valve surgery
  - 31.0%: Mitral + Tricuspid Valve surgery
  - 3.3%: Aortic + Tricuspid Valve surgery
  - 7.9%: Triple valve surgery

Primary:

- Rheumatic Heart Disease
- Degenerative Valve Disease

} >90%

Other Causes:

- Endocarditis
- Radiation
- Drugs (i.e. fen-phen)
- Connective tissue disease
- Genetic syndromes

Secondary:

- Malcoaptation

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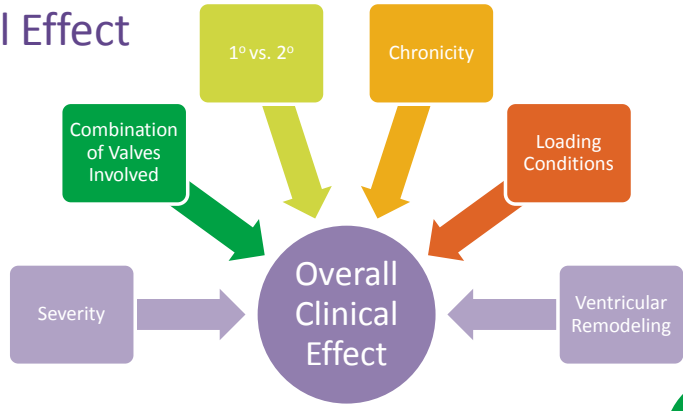
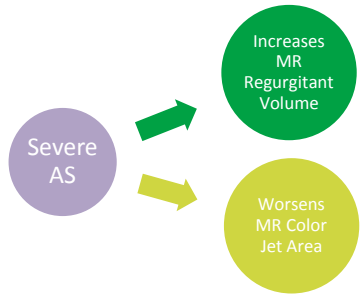
Unger, Philippe, et al. "Pathophysiology and management of multivalvular disease." *Nature Reviews Cardiology* (2016).

Clinical Effect



- **Grading severity:** Does the addition of a second lesion:
  1. Modify the actual severity of the primary lesion?
  2. Affect the quantification and grading of the primary lesion?



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ASE GUIDELINES AND STANDARDS

Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

William A. Zoghbi, MD, FASE (Chair), David Adams, RCS, RDCS, FASE, Robert O. Bonow, MD, Maurice Enriquez-Sarano, MD, Elyse Foster, MD, FASE, Paul A. Grayburn, MD, FASE, Rebecca T. Hahn, MD, FASE, Yuchi Han, MD, MMSc,* Judy Hung, MD, FASE, Roberto M. Lang, MD, FASE, Stephen H. Little, MD, FASE, Dipan J. Shah, MD, MMSc,* Stanton Shernan, MD, FASE, Paaladinesh Thavendiranathan, MD, MSc, FASE,* James D. Thomas, MD, FASE, and Neil J. Weissman, MD, FASE, *Houston and Dallas, Texas; Durham, North Carolina; Chicago, Illinois; Rochester, Minnesota; San Francisco, California; New York, New York; Philadelphia, Pennsylvania; Boston, Massachusetts; Toronto, Ontario, Canada; and Washington, DC*

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Table 17 Impact of multivalvular disease on assessment of valvular regurgitation with Doppler echocardiography and CMR

By this Valvular Lesion	Impact on this Regurgitant Lesion: AR	MR	PR	TR
AS	Little impact, although hemodynamically significant AR will increase AS gradient. **For CMR: phase-contrast plane better in LVOT**	For constant ROA, RVol increases in proportion to square root of excess pressure; jet area exaggerated beyond this. ROA may increase if LV dilates.	Little impact unless PH ensues.	Little impact unless PH ensues.
AR	NA	LV dilation may increase ROA (especially in secondary MR). Mixed regurgitant lesions render volumetric methods challenging, as one must find some location reflective of net forward flow (e.g., RVOT). **For CMR: MV RVol = LVSV - aortic forward flow; MR Reg fraction = MR RVol/ (LVSV - AR Rvol).**	Little impact unless PH ensues.	Little impact unless PH ensues.
MS	Little direct impact, although the delayed LV filling might theoretically lengthen AR pressure half-time.	If MV is heavily calcified, may shadow and decrease jet area and appearance of jet.	Lesion most likely to increase PAP and thus worsen RVol and jet area.	Lesion most likely to increase PAP and thus worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
MR	Little direct impact, but mixed regurgitant lesions render volumetric methods challenging, as one must find some location reflective of net forward flow (e.g., RVOT). Rapid early filling may decrease AR pressure half-time	NA	Likely to increase PAP and thus worsen RVol and jet area.	Likely to increase PAP and thus worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
PS	Little direct impact	Little direct impact	Little impact, although PR will exacerbate PS gradient. **For CMR: phase-contrast plane better in RVOT.**	Increased RVSP will worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
PR	Little direct impact	Little direct impact	NA	Increased RV volume may increase ROA, which will worsen RVol and jet area. **For CMR: TV RVol = RVSV - pulmonic forward flow. TR Reg fraction = TR RVol/ (RVSV - PR RVol).**
TS	Little direct impact	Little direct impact	Little direct impact	Little direct impact, although TR will exacerbate TS gradient.
TR	Little direct impact	Little direct impact	Rapid RV filling from TR may further shorten PR pressure half-time, and color PR jet more brief.	NA

AS, Aortic stenosis; *MS*, mitral stenosis; *NA*, not applicable; *PAP*, pulmonary artery pressure; *PH*, pulmonary hypertension; *PS*, pulmonic stenosis; *Reg*, regurgitant; *ROA*, regurgitant orifice area; *RVSP*, right ventricular systolic pressure; *TS*, tricuspid stenosis. CMR-related considerations are in bold.

Treatment for Multiple Valve Lesions

If you're already going to the OR, what is the indication to treat:

	Class I	Class IIa	Class IIb
Severe AS	X		
Moderate AS		X	
Severe AR	X		
Moderate AR		X	
Severe 1º MR	X		
Moderate 1º MR		X	
Severe 2º MR		X	
Moderate 2º MR			X
Severe TR	X		
TR and Annular Dilatation or Right Sided Failure		X	
Moderate TR and Pulm HTN			X

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Unger, Philippe, et al. "Pathophysiology and management of multivalvular disease." *Nature Reviews Cardiology* (2016). ACC/AHA Valve Guidelines

Treatment

Surgical Risk

- EuroHeart Survey:
  - 6.5% in hospital mortality for multi-valve surgery compared with 0.9%-3.9% for single valve surgery
- STS Database:
  - 10.7% in hospital mortality for multi-valve surgery compared with 5.7% for single valve surgery
    - 10.7% for combined AV and MV surgery
    - 4.9% for isolated AV surgery
    - 6.9% for isolated MV surgery
- Good long-term survival and clinical improvement at experienced centers
  - Preferred treatment strategy

What if surgery is not an option?

- Percutaneous Options?
- Staged Approach vs. Simultaneous Treatment

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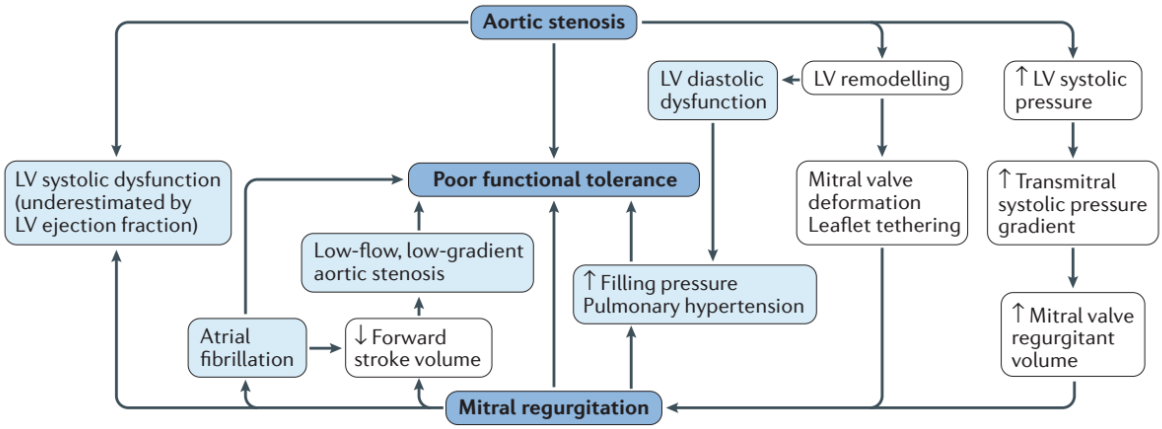
Unger, Philippe, et al. "Pathophysiology and management of multivalvular disease." *Nature Reviews Cardiology* (2016).

AS and MR

Clinical Impact for Each is Compounded by the Other



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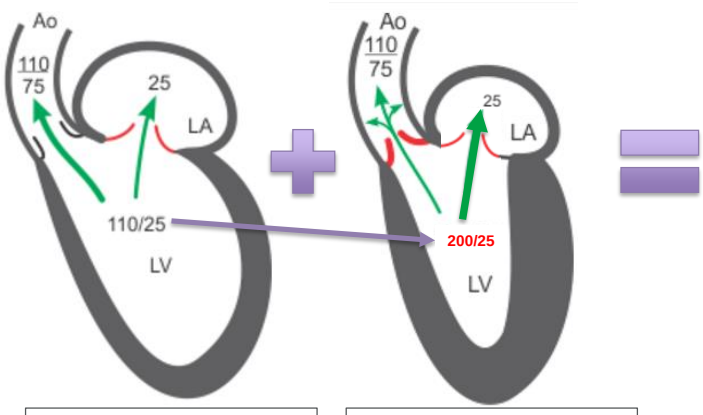
Unger, Philippe, et al. "Pathophysiology and management of multivalvular disease." *Nature Reviews Cardiology* (2016).

AS and MR

How does AS affect MR?



Mitral Regurgitation | Aortic Stenosis

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Increased Transmitral Gradient

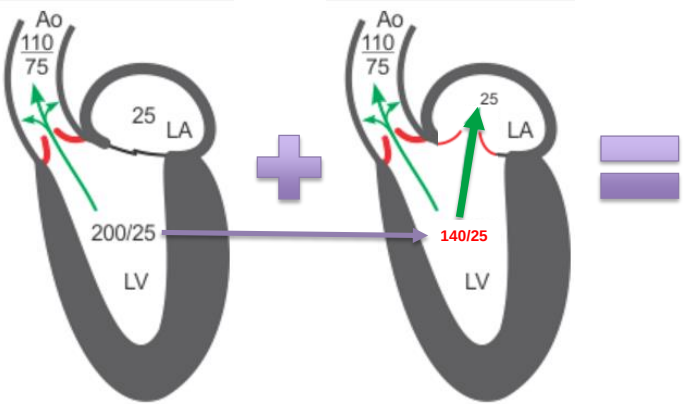
↓

Increased Regurgitant Volume

http://www.cvphysiology.com/Heart%20Disease/HD004

AS and MR

How does MR affect AS?



Aortic Stenosis | Mitral Regurgitation

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Low Flow State

↓

Lower Transaortic Pressure Gradient

↓

Lower Cardiac Output

http://www.cvphysiology.com/Heart%20Disease/HD004

AS and MR

Effect on Ejection Fraction after Correction

	MR	AS	Both
Effect on EF	↓	↑	↔ ↑

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Multivalvular Disease

- What is the net clinical effect of multiple valvular lesions?
- How do we grade severity of each lesion?
- What is the optimal treatment strategy?

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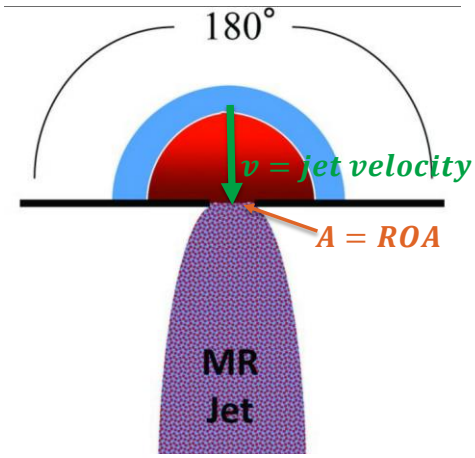
Echo Evaluation

Color Jet Area

- Jet size is highly dependent on jet momentum (M)
  - Momentum is conserved throughout the jet
  - $Flow\ (Q)\ =\ Av$
  - $M\ =\ Qv\ =\ Av^2$
- Simplified Bernoulli: $\Delta p\ =\ 4v^2$
  - $v \propto \sqrt{\Delta p}$
- $\therefore Q \propto \sqrt{\Delta p}$ AND $M \propto \Delta p$



Jet Size $\propto M$

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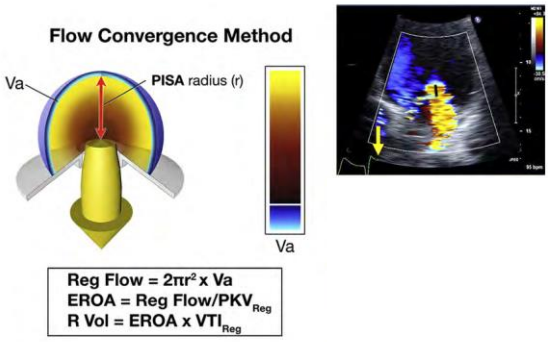
Thomas, et al. *Circulation* 1990; 81: 247-259

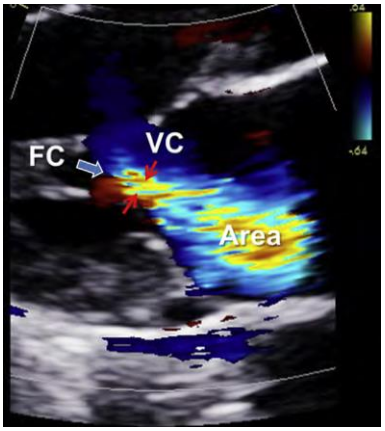
Echo Evaluation

Grading MR

Effective Regurgitant Orifice Area (PISA):



Vena Contracta:



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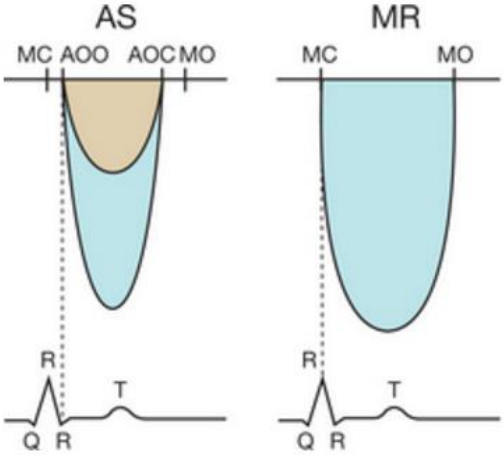
Zoghbi, William A., et al. "Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation." *Journal of the American Society of Echocardiography* 30.4 (2017): 303-371.

Echo Evaluation

AS Evaluation



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- Don't confuse AS and MR jets!

"Cardiac Valves." Thoracic Key. N.p., 04 June 2016. Web. 12 May 2017. <https://thoracickey.com/cardiac-valves/>.

Case 1: What is the optimal treatment strategy?

OR? Percutaneous? Fix AS? Fix MR? Fix Both?

- Surgical Risk Prohibitive
  - 2 elements of frailty
  - STS Scores:
    - SAVR: 7.6%
    - Mitral Valve Repair: 10.0%
    - Mitral Valve Replacement: 14.1%
    - No way to score double valve but certainly greater than 20%
- Plan for Percutaneous Approach
  - Simultaneous or staged?
  - Which order?

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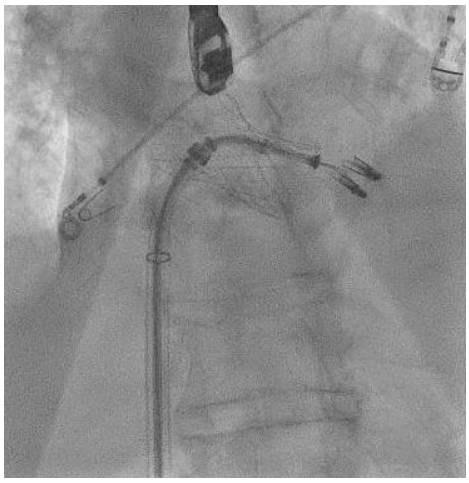
Percutaneous Double Valve Treatment

Feasibility of Staged Treatment



- 22 patients between Jan 2010 and Feb 2012 with severe AS and MR treated initially with TAVR
- 3 month follow up – 5 patients – the MR reduced to moderate with improvement in functional class (all functional without ischemic cardiomyopathy)
- 17 patients (77.3%) had persistent severe MR after 3 months
  - 12 patient had persistent symptoms and were treated with MitraClip
- Significant improvement in LVEF, MR grade, and functional status at 6 month follow up

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Kische, Stephan, et al. "Staged total percutaneous treatment of aortic valve pathology and mitral regurgitation: institutional experience." Catheterization and Cardiovascular Interventions 82.4 (2013): E552-E563.

What Happens to MR after TAVR?

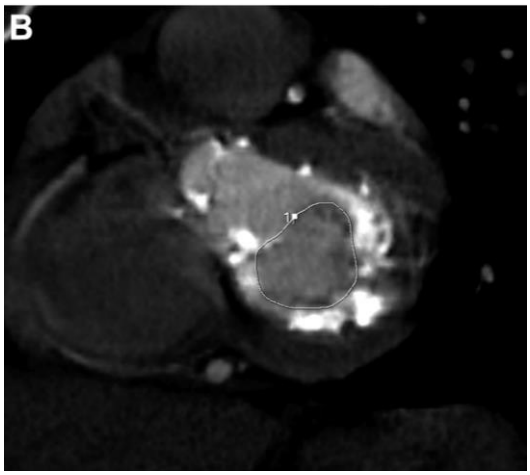
Predictors

TABLE 2 Independent Predictors of Persistent MR After TAVR

	OR	95% CI	p Value
Mitral leaflets calcification by MDCT (2 or 3)	3.942	1.208–12.864	**0.023**
Mitral annulus calcification by MDCT (2 or 3)	11.233	4.032–31.297	**<0.001**
Organic MR	2.594	0.858–7.845	0.091
NOAF	9.258	2.103–40.769	**0.003**
Persistent LBBB	2.503	0.921–6.800	0.072
SPPA	2.535	0.882–7.291	0.84
Mitral annulus diameter >35.5 mm	9.000	3.205–25.285	**<0.001**

Significant p values are in **bold**.

TAVR = transcatheter aortic valve replacement; other abbreviations as in Table 1.



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Cortés, Carlos, et al. "Mitral regurgitation after transcatheter aortic valve replacement: prognosis, imaging predictors, and potential management." JACC: Cardiovascular Interventions 9.15 (2016): 1603-1614.

Staged vs. Simultaneous

- Always fix AS first
  - May result in cardiac decompensation after MV repair in the presence of elevated afterload due to AS
- MR reduction in 60% of patients with **moderate functional** MR after isolated SAVR
- MR reduction in 30% of patients after TAVR
- LV Dysfunction, Afib, MV annular calcification, left atrial enlargement associated with MR progression
- Therefore, TAVR + maximal medical therapy
  - Reassess and consider MitraClip if still severe, symptomatic MR
- No increased risk or technical complexity of MitraClip in the presence of prior TAVR (assuming no distortion of the MV annulus)
- Simultaneous treatment has been described – consider in primary MR unlikely to recover significantly (may be tough to get paid for both!)

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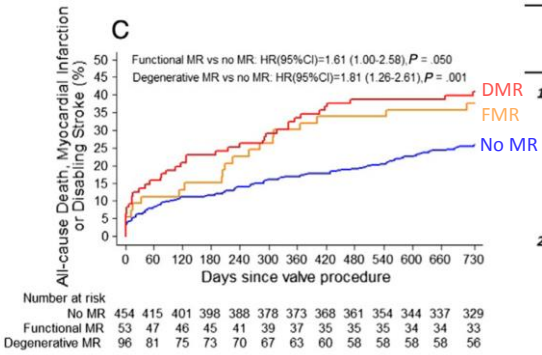
Kische, Stephan, et al. "Staged total percutaneous treatment of aortic valve pathology and mitral regurgitation: institutional experience." Catheterization and Cardiovascular Interventions 82.4 (2013): E552-E563.

Functional vs. Degenerative MR after TAVR

- 603 patients undergoing TAVR in single center for severe, symptomatic AS
- 149 (25%) with moderate or severe MR
  - 53 (36%) with functional MR (FMR)
  - 96 (64%) with degenerative MR (DMR)



	Adjusted HR (95% CI)	Adjusted Hazard ratio (95% CI) .5 1 2 4 8	Adjusted P-value
1 Year Follow-Up			
All Cause Death			
Functional vs No/Mild MR	1.18 (0.60-2.34)		0.635
Degenerative vs No/Mild MR	2.21 (1.39-3.52)		0.001
Cardiovascular Death			
Functional vs No/Mild MR	1.73 (0.82-3.67)		0.152
Degenerative vs No/Mild MR	2.85 (1.67-4.86)		<0.001
2 Years Follow-Up			
All Cause Death			
Functional vs No/Mild MR	0.95 (0.53-1.69)		0.853
Degenerative vs No/Mild MR	1.75 (1.18-2.60)		0.006
Cardiovascular Death			
Functional vs No/Mild MR	1.13 (0.59-2.18)		0.707
Degenerative vs No/Mild MR	2.21 (1.40-3.49)		0.001

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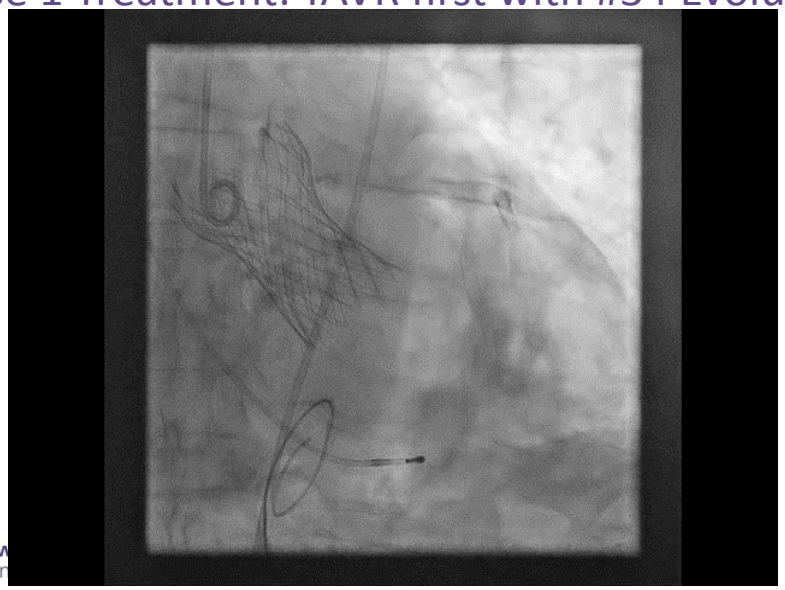
Vollenbroich, René, et al. "The impact of functional vs degenerative mitral regurgitation on clinical outcomes among patients undergoing transcatheter aortic valve implantation." American Heart Journal 184 (2017): 71-80.

Case 1 Treatment: TAVR first with #34 Evolut



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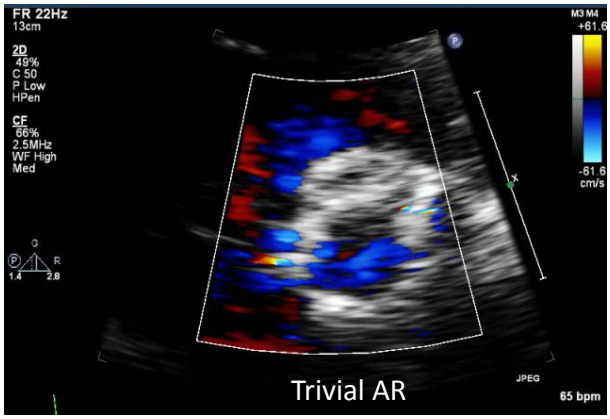
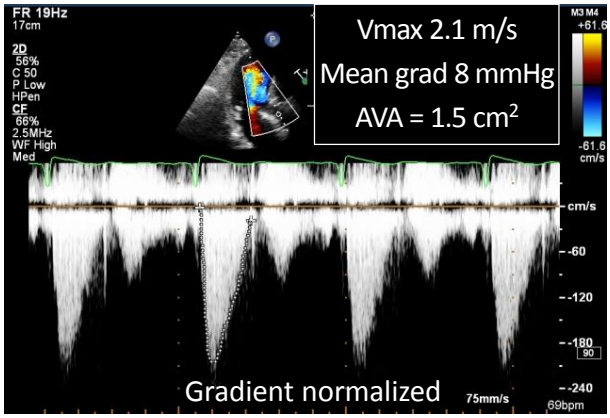
Post TAVR AV





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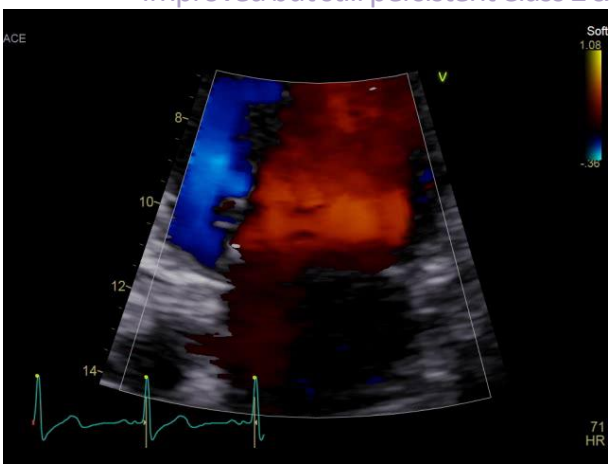
2 Month Follow Up

Improved but still persistent Class 2 sx

MR EROA = 0.4 cm2

Mitral Regurgitant Volume = 61 mL

Mitral Mean Grad = 3 mmHg (HR 72)



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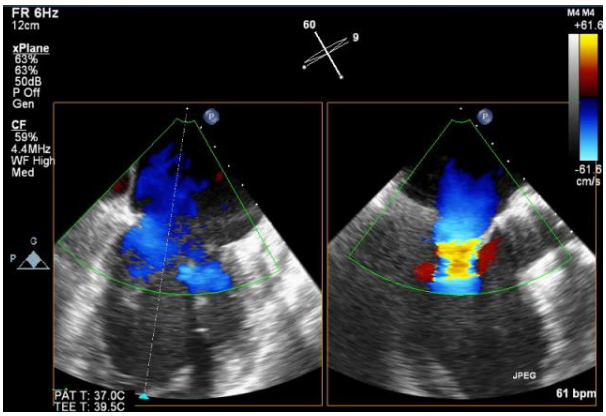
Continued severe organic MR

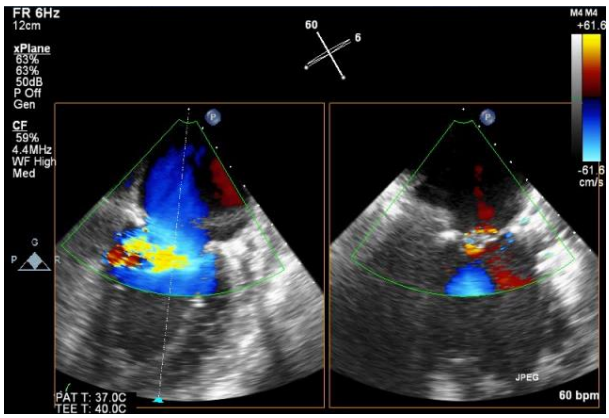
TEE

A2-P2



Flail P2 with severe MR

A1-P1



Small central leak laterally

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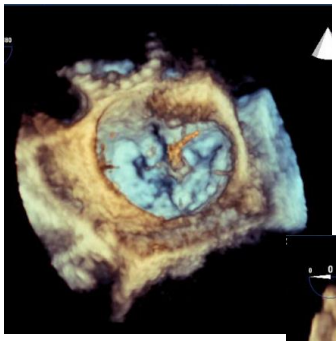
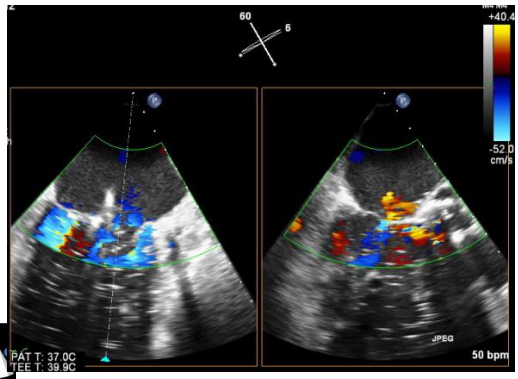
MitraClip: 2 clips on A2-P2





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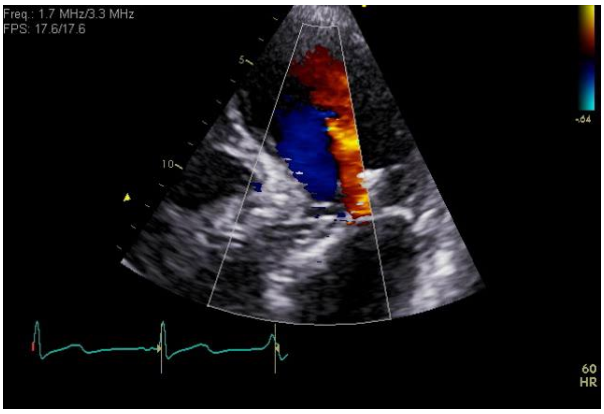
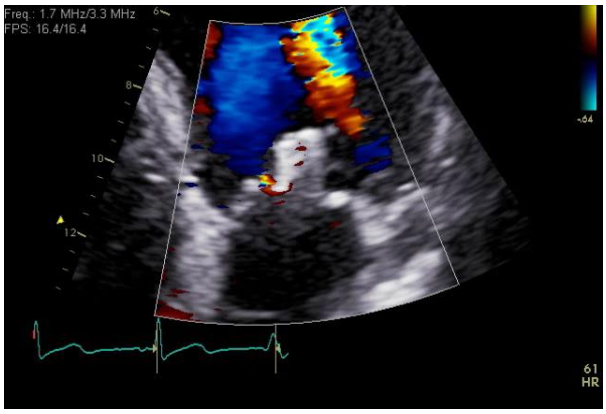
Final Result:
Trivial MR
Mean MV gradient = 4 mmHg
(HR 50)

1 Month Follow Up





Vmax = 2.1 m/s
Mean AV gradient = 9 mmHg
AVA = 1.23 cm^2

Trivial to mild MR
Mean MV gradient = 4 mmHg (HR 61)

Climbed Kilimanjaro last summer!

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OK, that's a lie, but he's Class 1 FC, riding a stationary bike daily

Case 2

- 84 year old female presents as an external transfer for MitraClip evaluation during an admission for a heart failure exacerbation, chest pain and tachycardia.

- Past Medical History
  - PE s/p IVC filter
  - HTN
  - HL
  - Breast Ca s/p Right mastectomy
  - GERD

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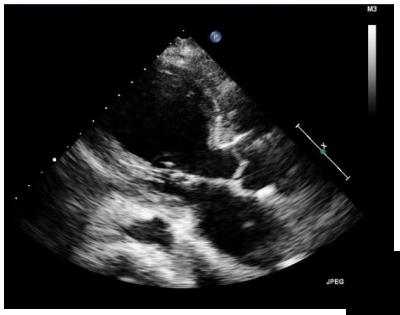
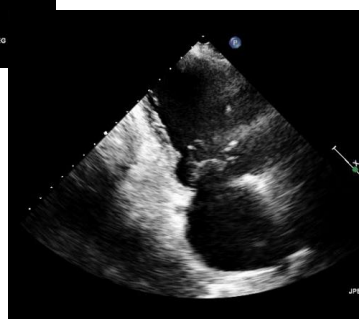
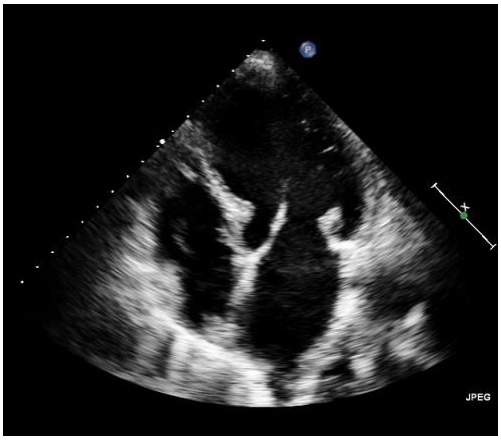
Case 2







- Normal LV Systolic Function
- Severely Dilated LA and LV

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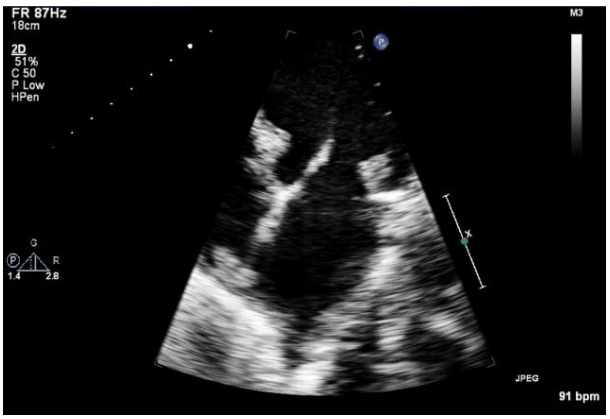
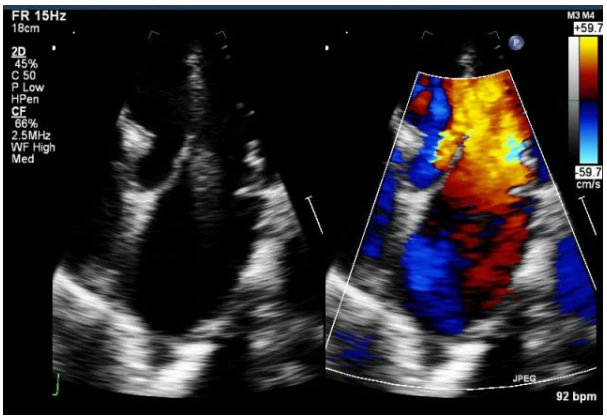
MR

Severely prolapsed vs. flail posterior leaflet





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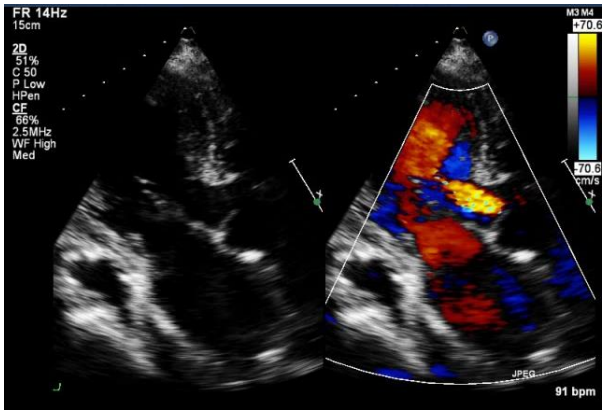
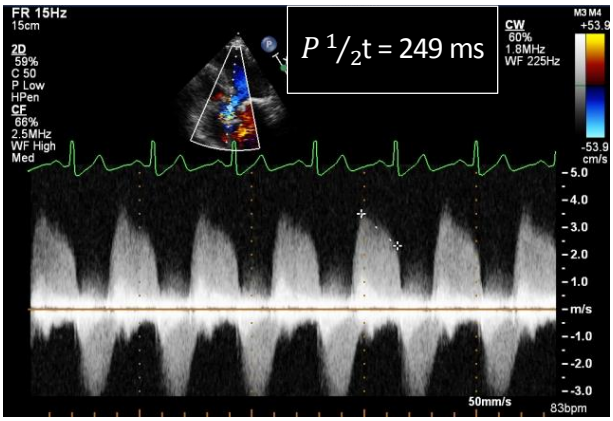
AR





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Multivalvular Disease

- What is the net clinical effect of multiple valvular lesions?
- How do we grade severity of each lesion?
- What is the optimal treatment strategy?

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ASE GUIDELINES AND STANDARDS

Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

William A. Zoghbi, MD, FASE (Chair), David Adams, RCS, RDCS, FASE, Robert O. Bonow, MD, Maurice Enriquez-Sarano, MD, Elyse Foster, MD, FASE, Paul A. Grayburn, MD, FASE, Rebecca T. Hahn, MD, FASE, Yuchi Han, MD, MMSc,* Judy Hung, MD, FASE, Roberto M. Lang, MD, FASE, Stephen H. Little, MD, FASE, Dipan J. Shah, MD, MMSc,* Stanton Sherman, MD, FASE, Paaladinesh Thavendiranathan, MD, MSc, FASE,* James D. Thomas, MD, FASE, and Neil J. Weissman, MD, FASE, *Houston and Dallas, Texas; Durham, North Carolina; Chicago, Illinois; Rochester, Minnesota; San Francisco, California; New York, New York; Philadelphia, Pennsylvania; Boston, Massachusetts; Toronto, Ontario, Canada; and Washington, DC*

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Table 17 Impact of multivalvular disease on assessment of valvular regurgitation with Doppler echocardiography and CMR

By this Valvular Lesion	Impact on this Regurgitant Lesion: AR	MR	PR	TR
AS	Little impact, although hemodynamically significant AR will increase AS gradient. **For CMR: phase-contrast plane better in LVOT**	For constant ROA, RVol increases in proportion to square root of excess pressure; jet area exaggerated beyond this. ROA may increase if LV dilates.	Little impact unless PH ensues.	Little impact unless PH ensues.
AR	NA	LV dilation may increase ROA (especially in secondary MR). Mixed regurgitant lesions render volumetric methods challenging, as one must find some location reflective of net forward flow (e.g., RVOT). **For CMR: MV RVol = LVSV - aortic forward flow; MR Reg fraction = MR RVol/(LVSV - AR RVol).**	Little impact unless PH ensues.	Little impact unless PH ensues.
MS	Little direct impact, although the delayed LV filling might theoretically lengthen AR pressure half-time.	If MV is heavily calcified, may shadow and decrease jet area and appearance of jet.	Lesion most likely to increase PAP and thus worsen RVol and jet area.	Lesion most likely to increase PAP and thus worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
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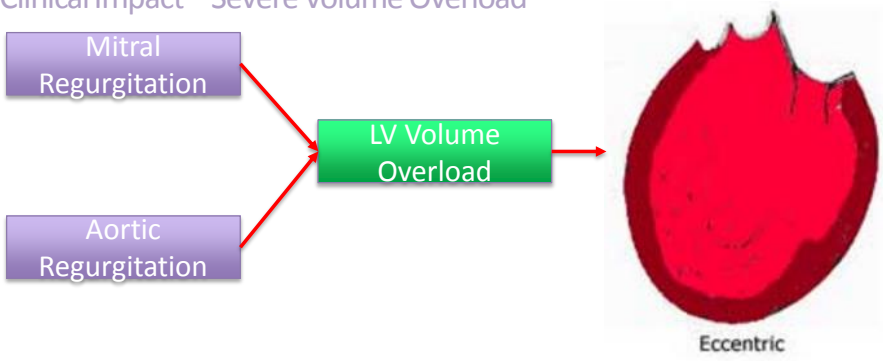
PS	Little direct impact	Little direct impact	Little impact, although PR will exacerbate PS gradient. **For CMR: phase-contrast plane better in RVOT.**	Increased RVSP will worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
PR	Little direct impact	Little direct impact	NA	Increased RV volume may increase ROA, which will worsen RVol and jet area. **For CMR: TV RVol = RVSV - pulmonic forward flow. TR Reg fraction = TR RVol/(RVSV - PR RVol).**
TS	Little direct impact	Little direct impact	Little direct impact	Little direct impact, although TR will exacerbate TS gradient.
TR	Little direct impact	Little direct impact	Rapid RV filling from TR may further shorten PR pressure half-time, and color PR jet more brief.	NA

AS, Aortic stenosis; *MS*, mitral stenosis; *NA*, not applicable; *PAP*, pulmonary artery pressure; *PH*, pulmonary hypertension; *PS*, pulmonic stenosis; *Reg*, regurgitant; *ROA*, regurgitant orifice area; *RVSP*, right ventricular systolic pressure; *TS*, tricuspid stenosis. CMR-related considerations are in bold.

AR and MR

Clinical Impact – Severe Volume Overload



- Very Poorly tolerated
- Post-operatively:
  - High incidence of LV Dysfunction
  - Reduced survival
  - Often persistent symptoms

Adapted from Katz, Physiology of the Heart (3rd ed), 2001

Multivalvular Disease

- What is the net clinical effect of multiple valvular lesions?
- How do we grade severity of each lesion?
- What is the optimal treatment strategy?

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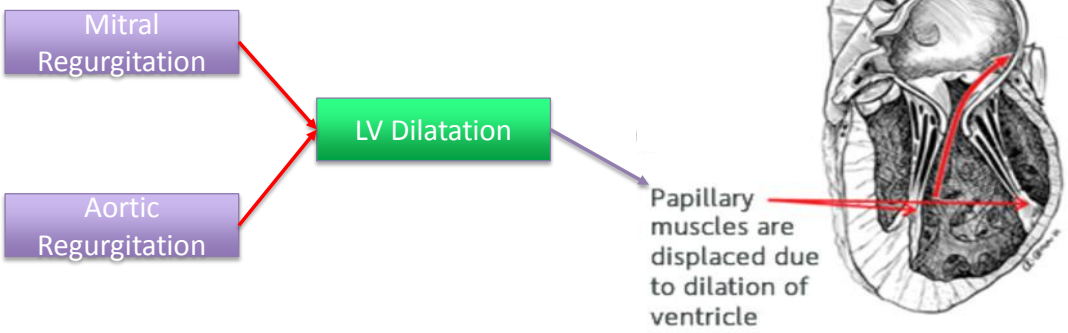
AR and MR

How does AR affect MR?



- **Increased ROA**

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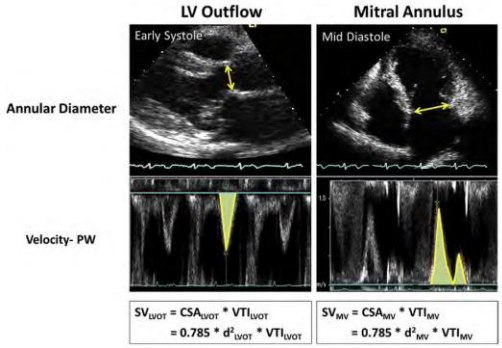
http://www.mardil.com/overview/

AR and MR

Volumetric Methods

Reference Stroke Volume:



- ~~$Reg\ Vol_{MR} = SV_{MV} - SV_{LVOT}$~~
- ~~$Reg\ Vol_{AR} = SV_{LVOT} - SV_{MV}$~~
- SV_{RVOT} ?
- **Direct measurement of forward and reverse flow by CMR**

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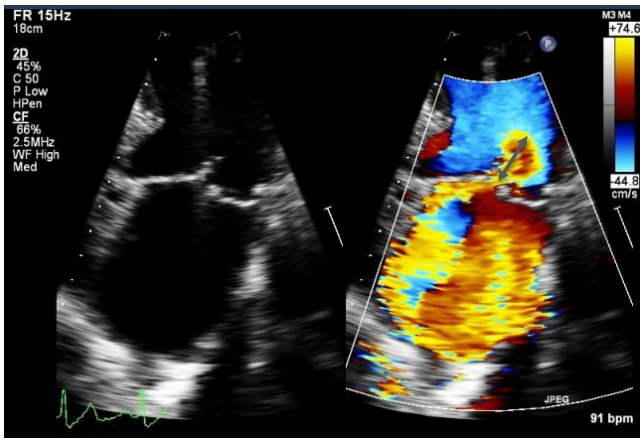
Zoghbi, William A., et al. "Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation." *Journal of the American Society of Echocardiography* 30.4 (2017): 303-371.

Echo Evaluation

Grading MR



- PISA Radius = 2 cm
- ERO = 1.6 cm^2
- Regurgitant Volume = 167 ml
- Systolic flow reversal noted in pulmonary veins

Severe MR

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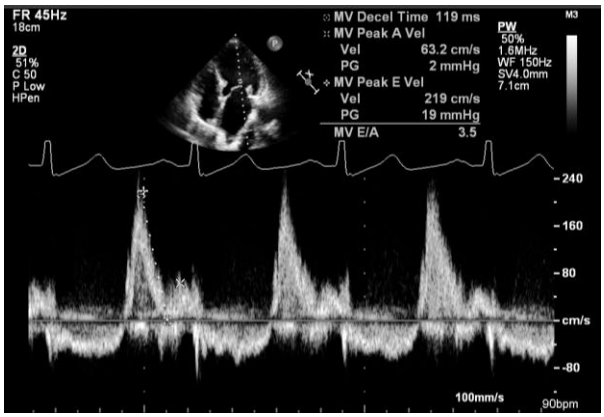
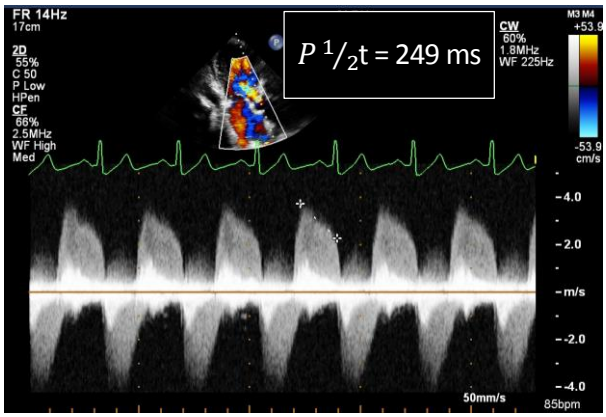
AR and MR

AR Pressure Half-Time





May overestimate severity of AR

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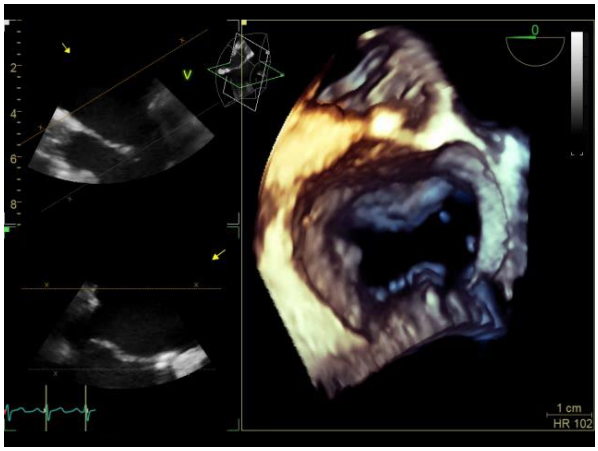
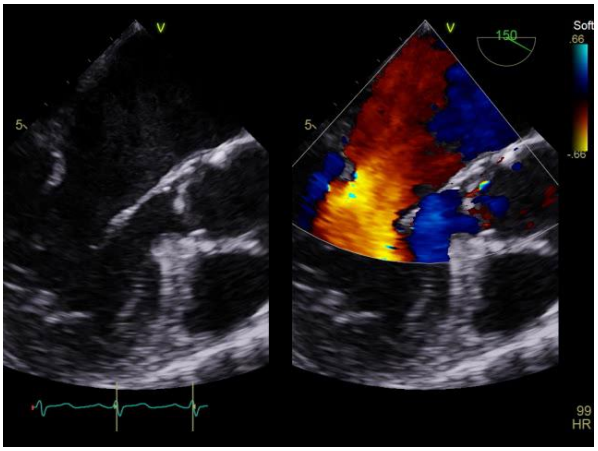
TEE

Flail P2





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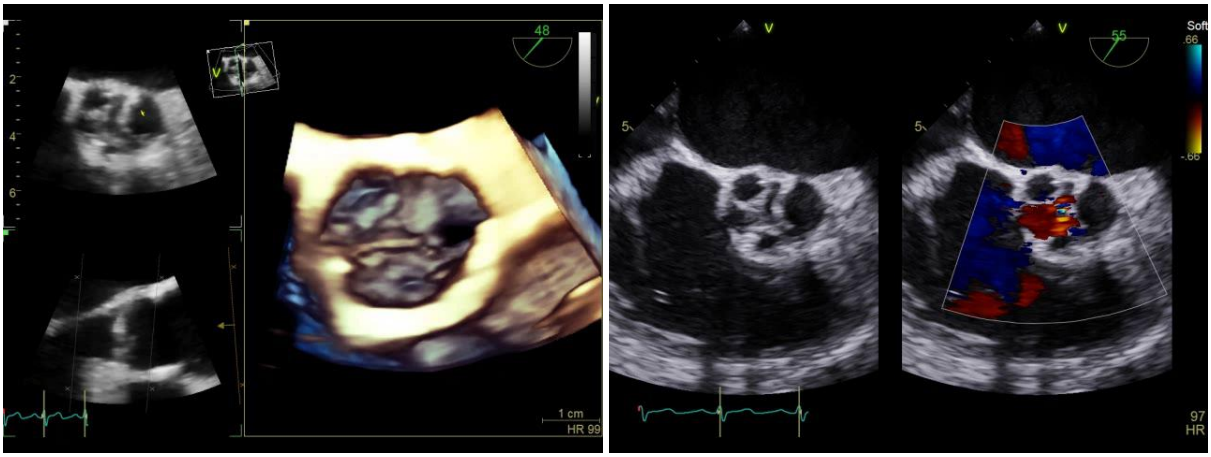
TEE



Mild to moderate AR

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Multivalvular Disease

- What is the net clinical effect of multiple valvular lesions?
- How do we grade severity of each lesion?
- What is the optimal treatment strategy?

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Case 2

Treatment

- Surgical Risk Prohibitive
  - 2 elements of frailty
  - STS Scores:
    - Mitral Valve Repair: 6.1%
    - Mitral Valve Replacement: 10.5%
- Treat MR with MitraClip

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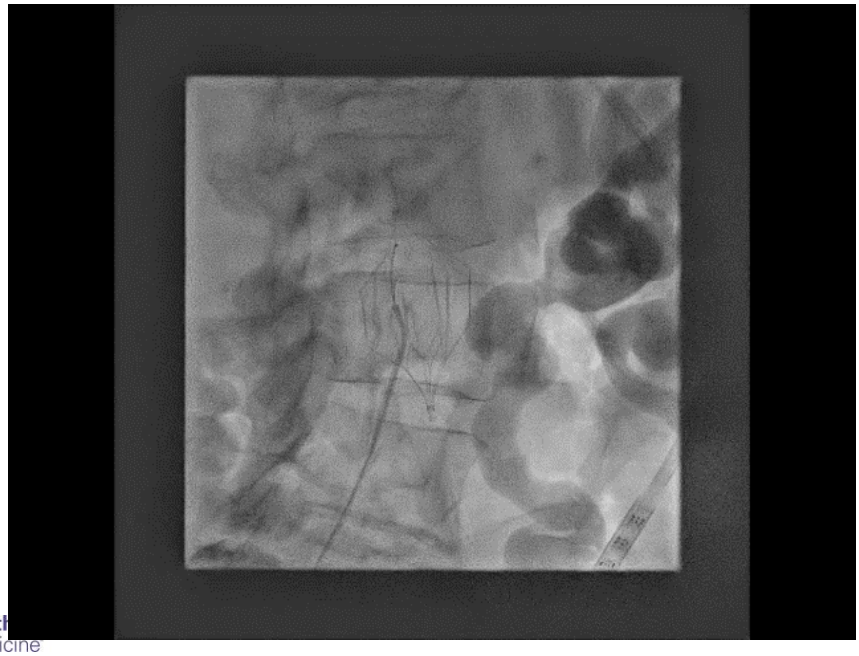
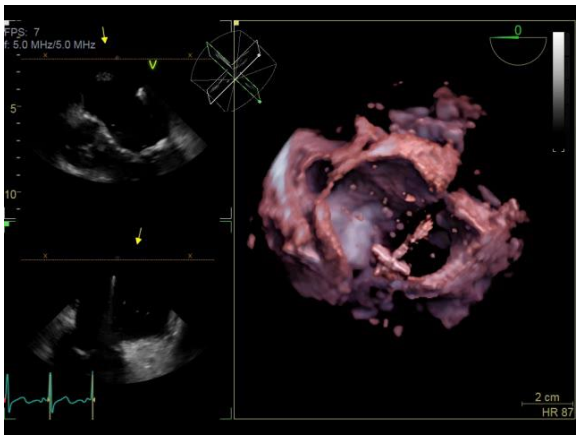
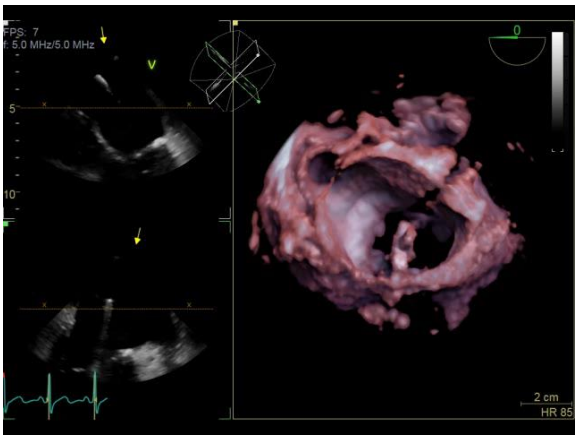


MitraClip

Positioning First Clip – Mid A2-P2





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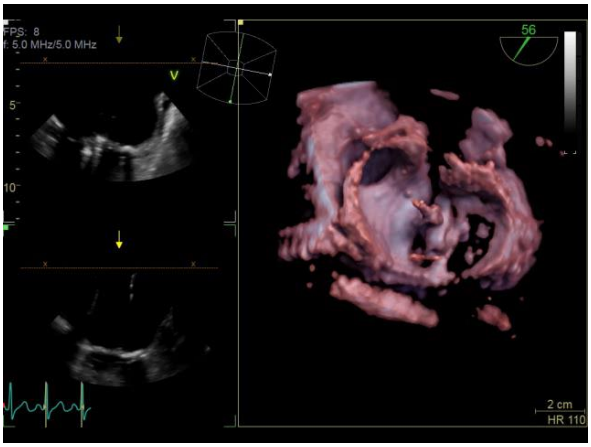
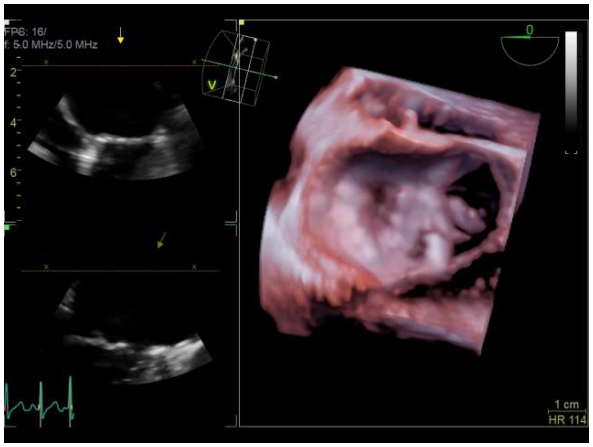
MitraClip

Second Clip at lateral aspect of A2-P2





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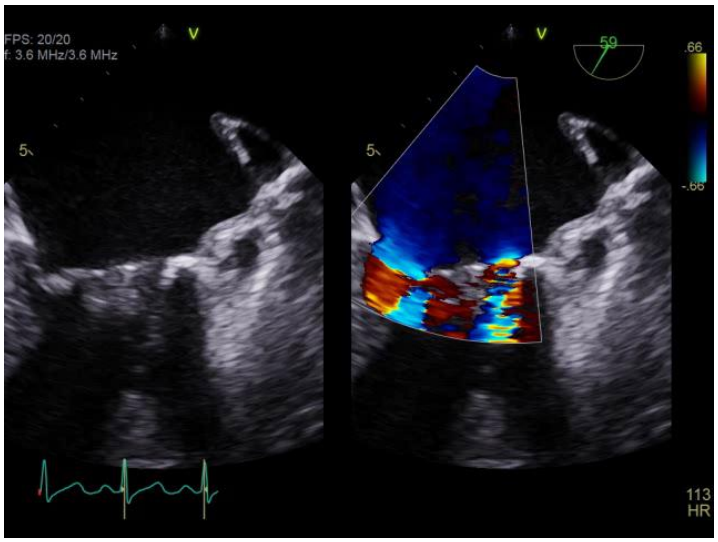
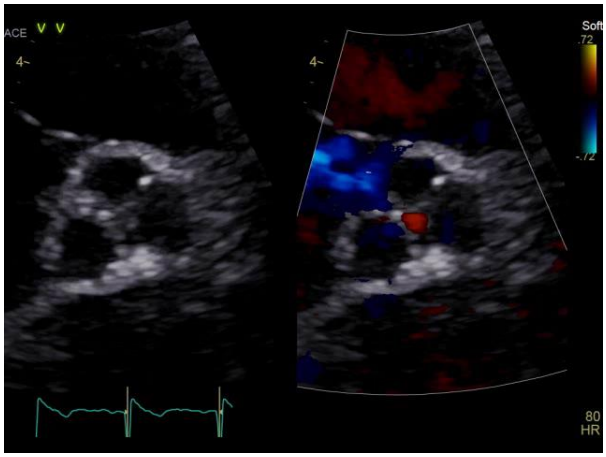
Final Result



Mild residual MR (central and lateral jets)
Mean MV gradient = 6 mmHg (HR 113)

1 Month Follow Up



Mild Aortic Regurgitation

Mild-mod MR (eccentric, anteriorly directed)
Mean MV gradient = 9 mmHg (HR 82)

Percutaneous Options for Aortic Regurgitation

CoreValve Evolut R (Medtronic)

- Self-expandable
- Repositionable (after partial deployment)
- More than mild residual AR in 20.9% (n=43)
  - 8 required second valve
- 30 day stroke incidence 4.7%
- 12 month all cause mortality 21.4%

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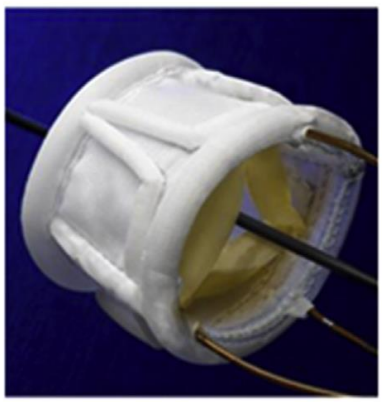
Roy, David A., et al. "Transcatheter aortic valve implantation for pure severe native aortic valve regurgitation." Journal of the American College of Cardiology 61.15 (2013): 1577-1584.

Percutaneous Options for Aortic Regurgitation

Direct Flow (Direct Flow Medical Inc.)



- Inflatable
- Repositionable after full deployment
- 11 high risk patients with pure, severe AR
- AR reduced to mild or less in all 11
- 1 patient required surgery for unstable valve
- 30 days:
  - 9% mortality
  - 0 strokes

RIP 11/30/16

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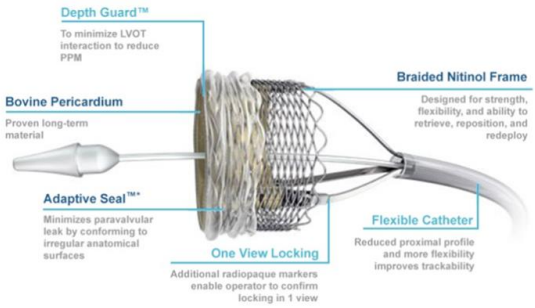
"Transcatheter options for the treatment of noncalcified aortic regurgitation." JACC: Cardiovascular Interventions 8.14 (2015).

Percutaneous Options for Aortic Regurgitation

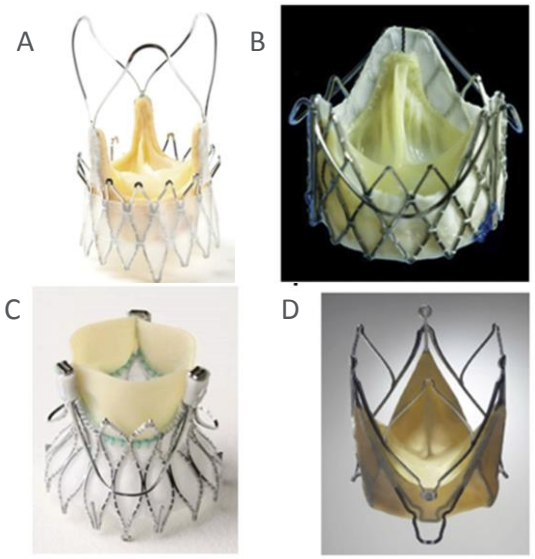
Lotus (Boston Scientific)



- Mechanically expanded
- Fully repositionable and retrievable
- Valve skirt allows anchoring to annulus and LVOT
- Limited experience
- Case series (3 patients)
  - No more than trace residual AR
  - Significant symptomatic improvement at follow up

1. http://www.bostonscientific.com/en-US/products/transcatheter-heart-valve/lotus-edge-valve-system.html
2. Saraf, Smriti, et al. "Use of the Lotus Transcatheter Valve to Treat Severe Native Aortic Regurgitation." The Annals of Thoracic Surgery 103.4 (2017): e305-e307.

Percutaneous Options for Aortic Regurgitation



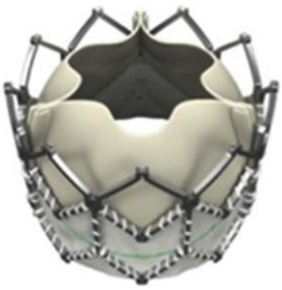
- A: **Accurate** (Symetic SA)
- B: **J-Valve** (JieCheng Medical Technology)
- C: **Engager** (Medtronic)
- D: **JenaValve** (JenaValve Technology)

- Self-seating geometry
  - Facilitates optimal positioning within the annulus
- Not repositionable
- Limited data is favorable for all of these

"Transcatheter options for the treatment of noncalcified aortic regurgitation." JACC: Cardiovascular Interventions 8.14 (2015).

Percutaneous Options for Aortic Regurgitation

Healio Transcatheter Dock with SAPIEN XT (Edwards Lifesciences)



- Nitinol frame placed in aortic root behind native leaflets
- Balloon-expandable valve deployed within
- Very limited data

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"Transcatheter options for the treatment of noncalcified aortic regurgitation." JACC: Cardiovascular Interventions 8.14 (2015).

Case 3

- 88 year old male presents was referred to NMH for consideration for percutaneous options for severe MR and TR. He was very active until about 6 months prior to presentation. Now with severe fatigue, LE edema, and dyspnea on exertion.

- <u>Past Medical History</u>
  - CAD s/p LIMA-LAD bypass
  - Atrial Fibrillation
  - Prostate Ca

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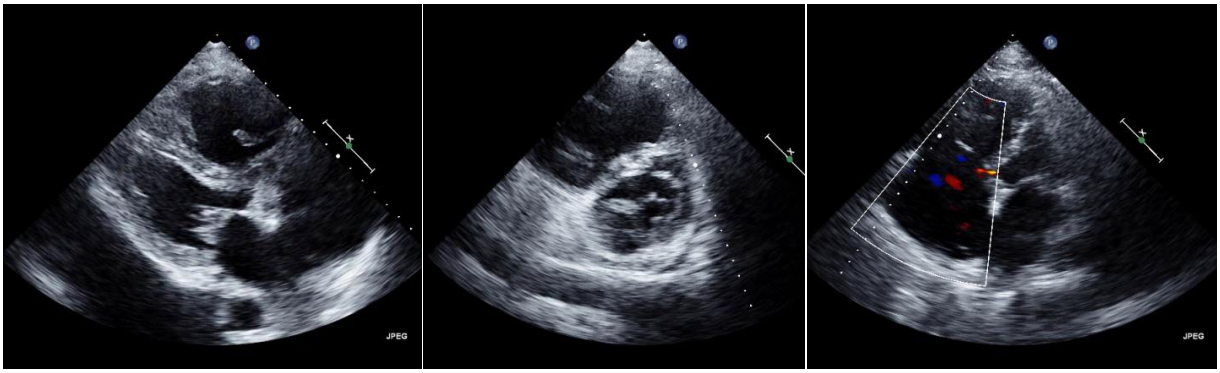
Echo

Severe TR, severely dilated RV and RA



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Echo

Severe MR – 2 Jets (A1-P1, A3-P3), EROA 0.5 cm^2

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ASE GUIDELINES AND STANDARDS

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AS, Aortic stenosis; *MS*, mitral stenosis; *NA*, not applicable; *PAP*, pulmonary artery pressure; *PH*, pulmonary hypertension; *PS*, pulmonic stenosis; *Reg*, regurgitant; *ROA*, regurgitant orifice area; *RVSP*, right ventricular systolic pressure; *TS*, tricuspid stenosis. CMR-related considerations are in bold.

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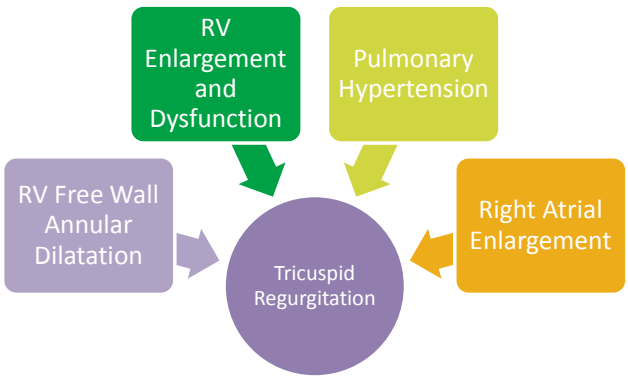
MR and TR

- Secondary TR is highly prevalent in patients with left-sided valvular disease



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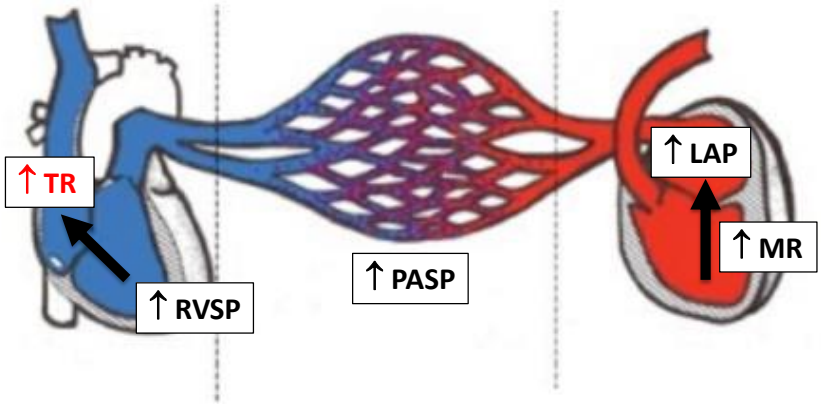
MR and TR

How does MR affect TR?



1. Increased Regurgitant Volume for given ROA
2. Increased Color Jet Area (out of proportion to increased Regurgitant Volume)
3. Increased ROA due to TV annular dilation

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http://www.rtmagazine.com/2010/08/pulmonary-hypertension-and-the-respiratory-therapists-role-in-diagnosis-and-treatment/

Case 3

Treatment

- Surgical Risk Prohibitive
  - 2 elements of frailty
  - STS Scores:
    - Mitral Valve Repair: 5%
    - Mitral Valve Replacement: 8%
- MR - MitraClip
- TR - MitraClip at the same time vs. return at a later date for percutaneous TV repair

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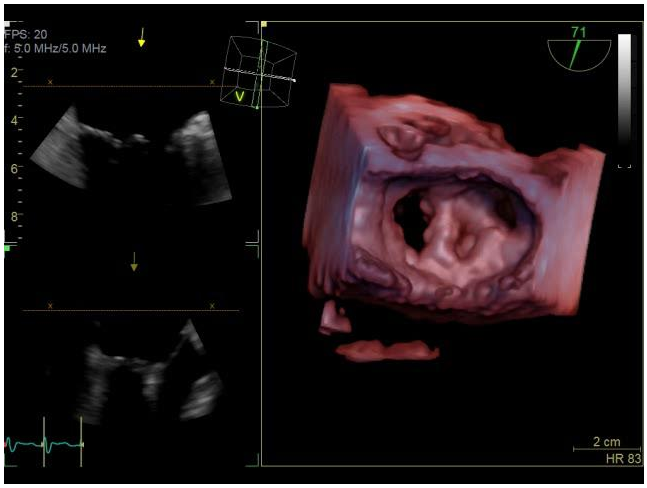
MitraClip



Final Result:

2 Clips (A1-P1, A3-P3)

Mild residual MR

MV mean gradient = 2 mmHg (HR 87)

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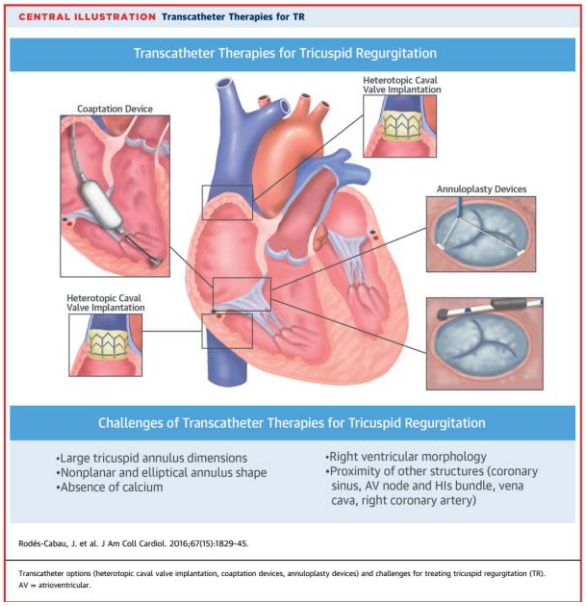

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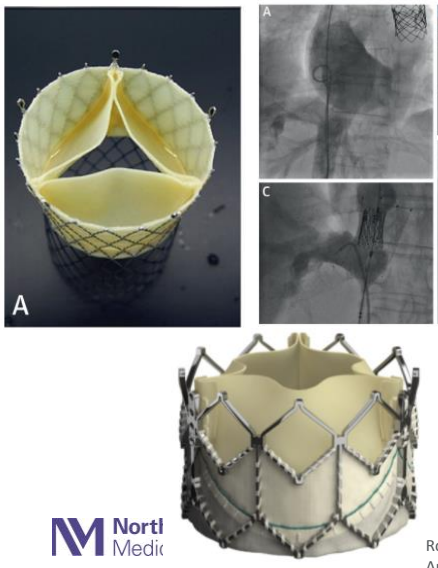
Rodés-Cabau, Josep, et al. "Transcatheter therapies for treating tricuspid regurgitation." Journal of the American College of Cardiology 67.15 (2016): 1829-1845.

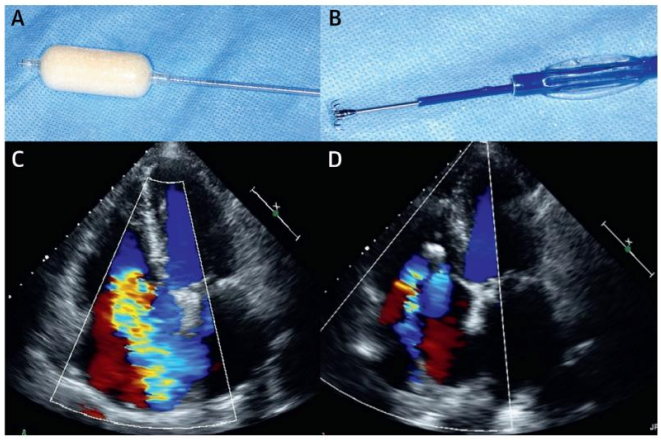
CAVI – Caval Valve Implantation



- Tric Valve
  - Designed for SVC and IVC
  - Self Expandable
- SAPIEN
  - Requires preparation of landing zone with a self-expanding stent
  - TRICAVAL and HOVER

Rodés-Cabau, Josep, et al. "Transcatheter therapies for treating tricuspid regurgitation." Journal of the American College of Cardiology 67.15 (2016): 1829-1845.

FORMA – Coaptation Device



- Rail which anchors to the RV apex
- Spacer that increases coaptation surface to reduce malcoaptation
- Feasibility trial ongoing

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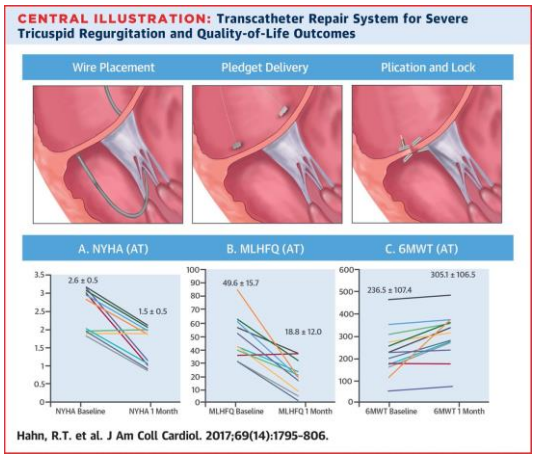
Rodés-Cabau, Josep, et al. "Transcatheter therapies for treating tricuspid regurgitation." Journal of the American College of Cardiology 67.15 (2016): 1829-1845.

SCOUT – Mitralign

30 Day Results



- 15 patients between Nov 2015 and June 2016
- Technical success rate 80%
  - 3 patients with single-pledget annular detachment
- TA area reduction:
  - 12.3 +/- 3.1 cm^2 to 11.3 +/- 2.7 cm^2; p=0.02
- EROA reduction:
  - 0.51 +/- 0.18 cm^2 to 0.32 +/- 0.18 cm^2; p = 0.02
- LVSV increase:
  - 63.6 +/- 19.9 ml to 71.5 +/- 25.7 ml; p=0.02

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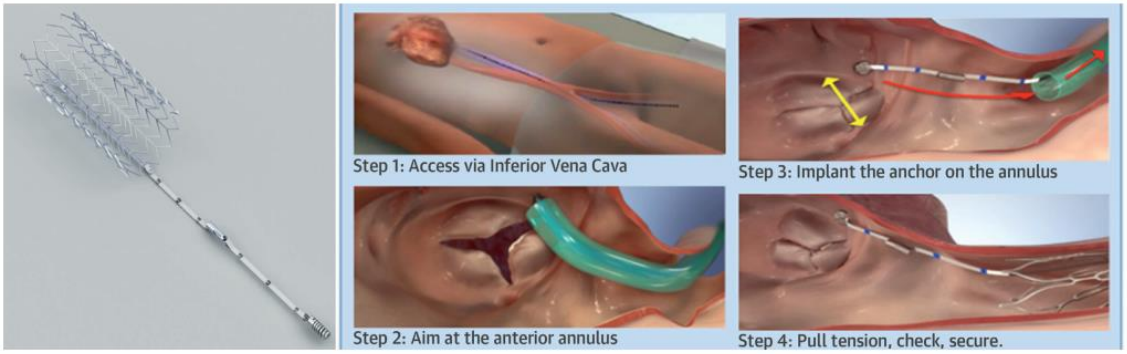
Hahn, Rebecca T., et al. "Early Feasibility Study of a Transcatheter Tricuspid Valve Annuloplasty: SCOUT Trial 30-Day Results." Journal of the American College of Cardiology 69.14 (2017): 1795-1806.

TriCinch



- Corkscrew anchor
- Self-expanding nitinol stent deployed in the IVC
- Dacron band connecting both
- PREVENT study

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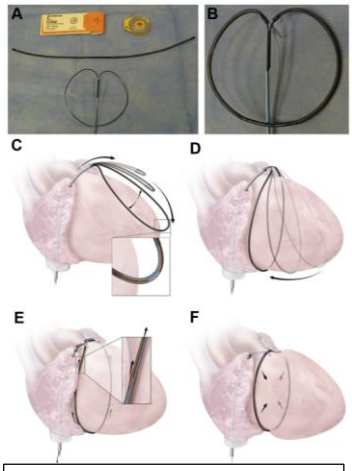
Rodés-Cabau, Josep, et al. "Transcatheter therapies for treating tricuspid regurgitation." Journal of the American College of Cardiology 67.15 (2016): 1829-1845.

Mitraclip on TV

Cardioband



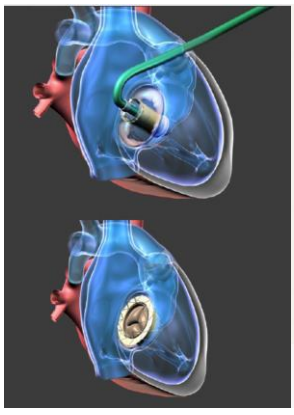
TRAIPTA

Millipede

Rogers, Toby, et al. "Transatrial intrapericardial tricuspid annuloplasty." JACC: Cardiovascular Interventions 8.3 (2015): 483-491.
http://www.valtechcardio.com/our-products/cardioband-tricuspid/

Percutaneous TV Replacement

Gate™ Tricuspid Valved Stent



Outflow view of Replacement Valve

- Nov 2016: World's first transcatheter tricuspid valved stent (transatrial)
- April 2017: Transjugular and placed into a failed annuloplasty ring
- Up to 48-50cm in diameter without protrusion into atria or ventricle

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https://www.navigatecsi.com/about/

Take Home Points

- Multivalvular Disease is common
- Complex inter-relationship resulting in overall clinical picture
- Grading severity can be a challenge
  - Actual severity and echo appearance affected
- Many new transcatheter options are in development

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ASE GUIDELINES AND STANDARDS

Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

William A. Zoghbi, MD, FASE (Chair), David Adams, RCS, RDCS, FASE, Robert O. Bonow, MD, Maurice Enriquez-Sarano, MD, Elyse Foster, MD, FASE, Paul A. Grayburn, MD, FASE, Rebecca T. Hahn, MD, FASE, Yuchi Han, MD, MMSc,* Judy Hung, MD, FASE, Roberto M. Lang, MD, FASE, Stephen H. Little, MD, FASE, Dipan J. Shah, MD, MMSc,* Stanton Shernan, MD, FASE, Paaladinesh Thavendiranathan, MD, MSc, FASE,* James D. Thomas, MD, FASE, and Neil J. Weissman, MD, FASE, *Houston and Dallas, Texas; Durham, North Carolina; Chicago, Illinois; Rochester, Minnesota; San Francisco, California; New York, New York; Philadelphia, Pennsylvania; Boston, Massachusetts; Toronto, Ontario, Canada; and Washington, DC*

Table 17 Impact of multivalvular disease on assessment of valvular regurgitation with Doppler echocardiography and CMR

By this Valvular Lesion	Impact on this Regurgitant Lesion			
	AR	MR	PR	TR
AS	Little impact, although hemodynamically significant AR will increase AS gradient. **For CMR: phase-contrast plane better in LVOT**	For constant ROA, RVol increases in proportion to square root of excess pressure; jet area exaggerated beyond this. ROA may increase if LV dilates.	Little impact unless PH ensues.	Little impact unless PH ensues.
AR	NA	LV dilation may increase ROA (especially in secondary MR). Mixed regurgitant lesions render volumetric methods challenging, as one must find some location reflective of net forward flow (e.g., RVOT). **For CMR: MV RVol = LVSV - aortic forward flow; MR Reg fraction = MR RVol/ (LVSV - AR Rvol).**	Little impact unless PH ensues.	Little impact unless PH ensues.
MS	Little direct impact, although the delayed LV filling might theoretically lengthen AR pressure half-time.	If MV is heavily calcified, may shadow and decrease jet area and appearance of jet.	Lesion most likely to increase PAP and thus worsen RVol and jet area.	Lesion most likely to increase PAP and thus worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
MR	Little direct impact, but mixed regurgitant lesions render volumetric methods challenging, as one must find some location reflective of net forward flow (e.g., RVOT). Rapid early filling may decrease AR pressure half-time	NA	Likely to increase PAP and thus worsen RVol and jet area.	Likely to increase PAP and thus worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
PS	Little direct impact	Little direct impact	Little impact, although PR will exacerbate PS gradient. **For CMR: phase-contrast plane better in RVOT.**	Increased RVSP will worsen RVol and jet area. If RV dysfunction occurs, may increase ROA.
PR	Little direct impact	Little direct impact	NA	Increased RV volume may increase ROA, which will worsen RVol and jet area. **For CMR: TV RVol = RVSV - pulmonic forward flow. TR Reg fraction = TR RVol/ (RVSV - PR RVol).**
TS	Little direct impact	Little direct impact	Little direct impact	Little direct impact, although TR will exacerbate TS gradient.
TR	Little direct impact	Little direct impact	Rapid RV filling from TR may further shorten PR pressure half-time, and color PR jet more brief.	NA

AS, Aortic stenosis; *MS*, mitral stenosis; *NA*, not applicable; *PAP*, pulmonary artery pressure; *PH*, pulmonary hypertension; *PS*, pulmonic stenosis; *Reg*, regurgitant; *ROA*, regurgitant orifice area; *RVSP*, right ventricular systolic pressure; *TS*, tricuspid stenosis. CMR-related considerations are in bold.

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