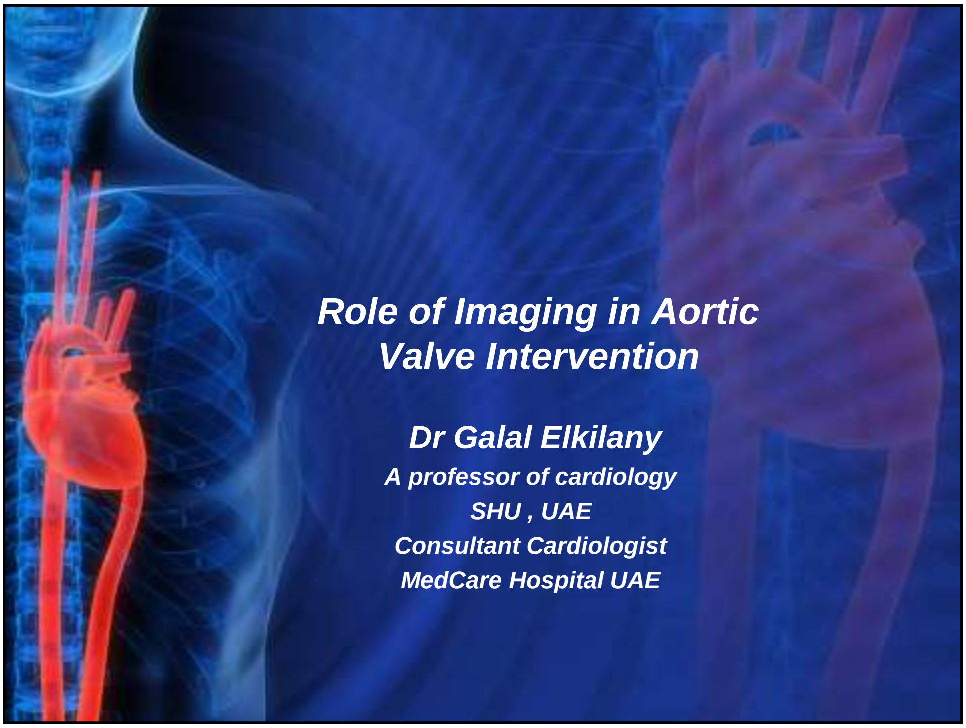
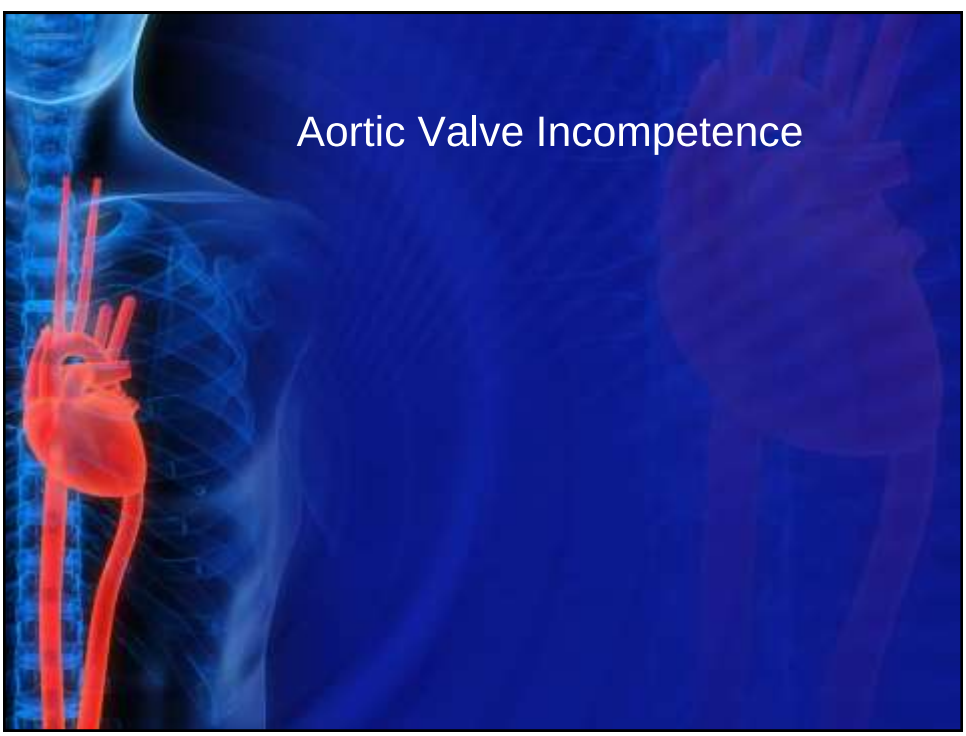

Role of Imaging in Aortic Valve Intervention
Dr Galal Elkilany
A professor of cardiology
SHU , UAE
Consultant Cardiologist
MedCare Hospital UAE


Aortic Valve Incompetence

Application of specific and supportive signs, and quantitative parameters in the grading of aortic regurgitation severity[4]

	Mild	Moderate		Severe
Specific signs for AR severity	Central Jet, width < 25% of LVOT[ς] • Vena contracta < 0.3 cm[ς] • No or brief early diastolic flow reversal in descending aorta •	Signs of AR>mild present but no criteria for severe AR •		Central Jet, width ≥ 65% of LVOT[ς] • Vena contracta > 0.6cm[ς] •
Supportive signs	Pressure half-time > 500 ms • Normal LV size* •	Intermediate values •		Pressure half-time < 200 ms • Holodiastolic aortic flow reversal in descending aorta • Moderate or greater LV enlargement** •
				Quantitative parameters[ψ]
R Vol, ml/beat	< 30	30-44	45-59	≥ 60
RF %	< 30	30-39	40-49	≥ 50
EROA, cm^2	< 0.10	0.10-0.19	0.20-0.29	≥ 0.30

AR, Aortic regurgitation; *EROA*, effective regurgitant orifice area; *LV*, left ventricle; *LVOT*, left ventricular outflow tract; *R Vol*, regurgitant volume; *RF*, regurgitant fraction. •

* LV size applied only to chronic lesions. Normal 2D measurements: LV minor-axis ≤ 2.8 cm/m^2, LV end-diastolic volume ≤ 82 ml/m^2 (2). •

ς At a Nyquist limit of 50–60 cm/s. •

** In the absence of other etiologies of LV dilatation. •

ψ Quantitative parameters can help sub-classify the moderate regurgitation group into mild-to-moderate and moderate-to-severe regurgitation as shown. •

- **Continuity equation**
- With the continuity equation you will be able to calculate the aortic valve area. The principle of the continuity equation is that the amount of flow before the valve (left ventricular outflow) equals the amount of flow across the valve:

Flow through aortic valve* = flow through LVOT*

Aortic valve area x aortic TVI = LVOT area x LVOT TVI

Aortic valve area = LVOT area x LVOT TVI / aortic TVI

$$\boxed{\text{Aortic valve area} = \frac{\text{LVOT diameter}^2 \times \Pi/4 \times \text{LVOT TVI}}{\text{Aortic TVI}}}$$

*Flow = valve area x time velocity integral (TVI)

1. Measurement of LVOT diameter

-parasternal long axis

-zoom on the aortic valve

-measurement of the aortic annulus diameter, at proto-diastole

-value should be around 18-25 mm

2. Measurement of LVOT TVI

-apical 5 chamber

-pulsed Doppler at the level of the LVOT

-negative flow (going away from the probe)

-trace the envelope of the flow

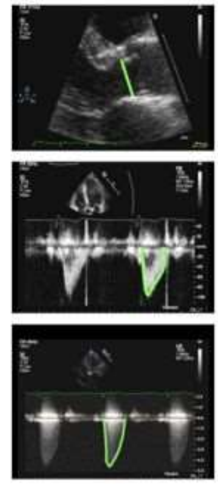
3. Measurement of aortic TVI

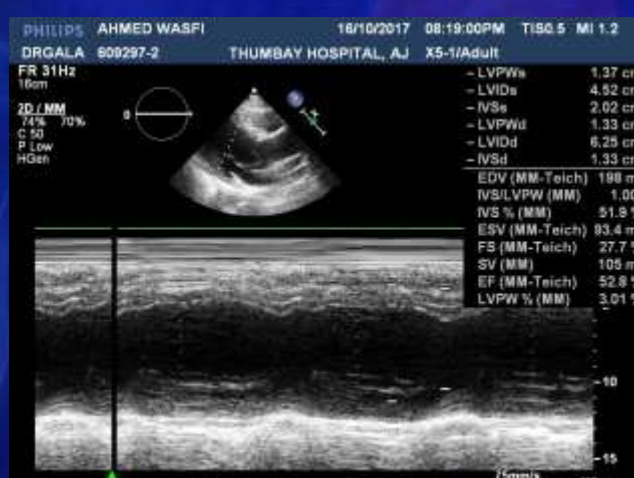
-apical 5 chamber

-continuous Doppler across the valve

-negative flow, high velocity

-trace the envelope of the flow





Recommendations for classification of AS severity

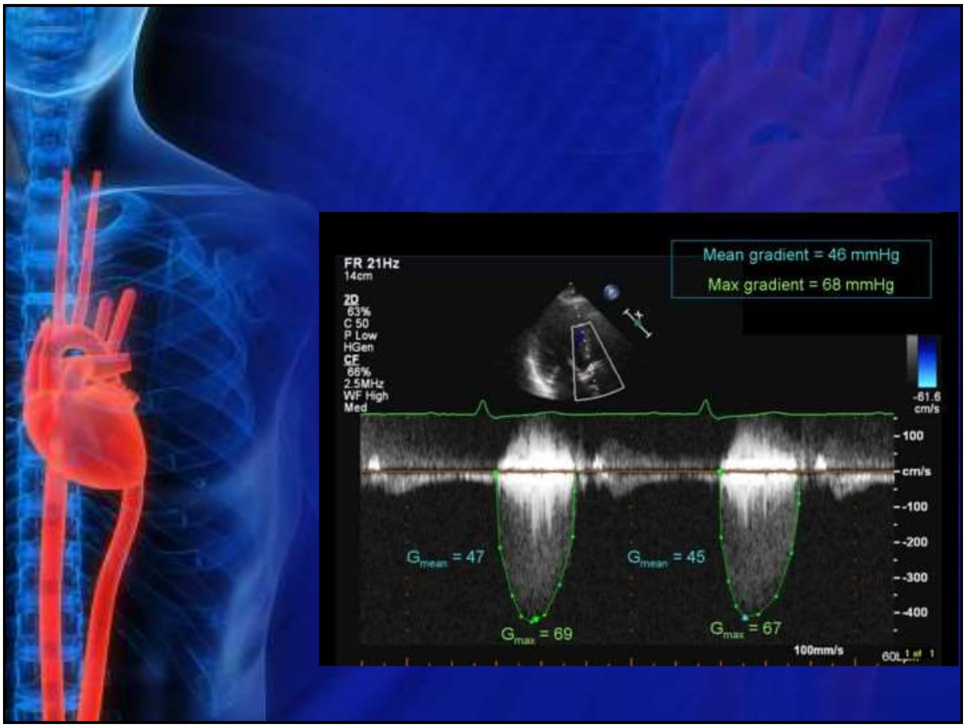
	Aortic sclerosis	Mild	Moderate	Severe
Aortic jet velocity (m/s)	≤2.5 m/s	2.6-2.9	3.0-4.0	>4.0
Mean gradient (mmHg)	-	<20 (<30[a])	20-40[b] (30-50[a])	>40[b] (>50[a])
AVA (cm^2)	-	>1.5	1.0-1.5	<1
Indexed AVA (cm^2/m^2)		>0.85	0.60-0.85	<0.6
Velocity ratio		>0.50	0.25-0.50	<0.25

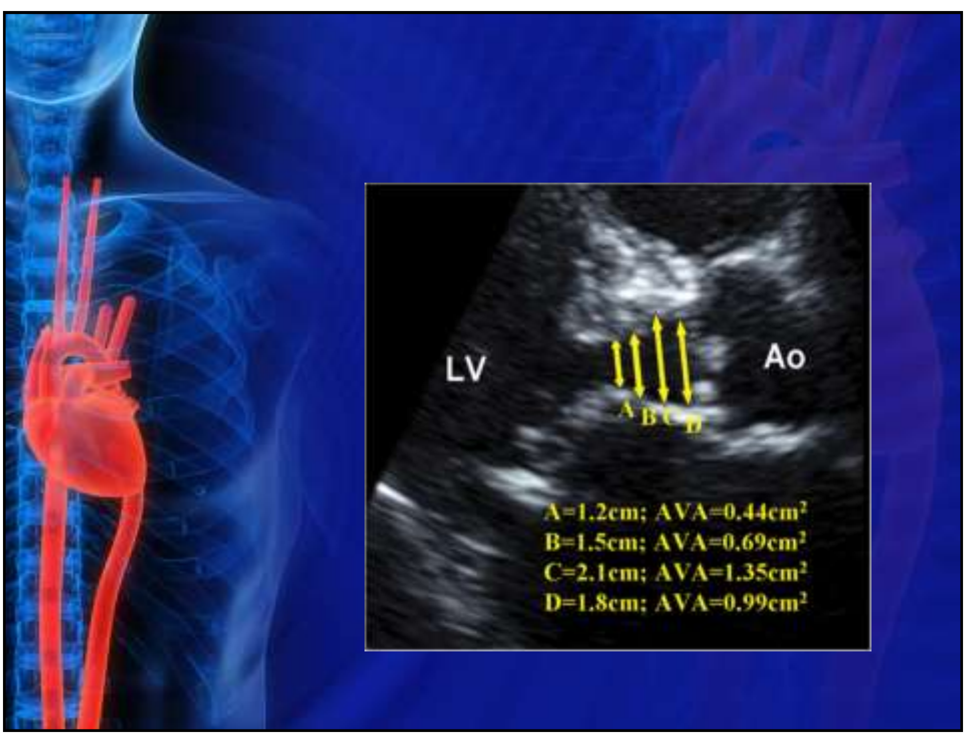
[a]ESC Guidelines.[2]•
[b]AHA/ACC Guidelines.[3]•

EAE/ASE RECOMMENDATIONS Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice

- Echocardiography has become the standard means for evaluation of aortic stenosis (AS) severity. Cardiac catheterization is no longer recommended except in rare cases when echocardiography is non-diagnostic or discrepant with clinical data.

- However, although accurate quantitation of disease severity is an essential step in patient management, clinical decision making depends on several other factors, most importantly symptom status.

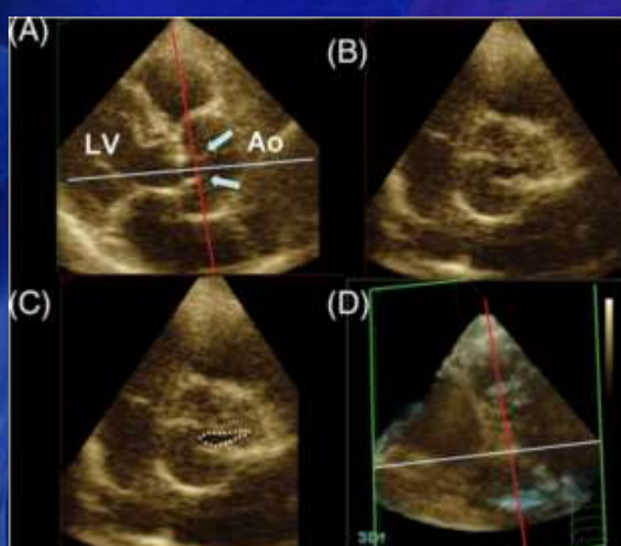

Mean gradient = 46 mmHg
Max gradient = 68 mmHg
FR 21Hz
14cm
2D
63%
C 50
P Low
HGen
CF
66%
2.5MHz
WF High
Med
-61.6
cm/s
100
cm/s
-100
-200
-300
-400
G_{mean} = 47
G_{mean} = 45
G_{max} = 69
G_{max} = 67
100mm/s


LV
Ao
A
B
C
D
A=1.2cm; AVA=0.44cm²
B=1.5cm; AVA=0.69cm²
C=2.1cm; AVA=1.35cm²
D=1.8cm; AVA=0.99cm²

Hybrid Lab.

- The use of fluoroscopy combined with two-dimensional and 3D echocardiography can improve the confidence of correct prosthetic valve placement. The sonographer should repeatedly alternate between biplane and 3D live mode in the long-axis view to allow the interventional and imaging cardiologists to obtain a better understanding of catheter location. Prosthetic location can be improved by the imaging team (cardiologist and sonographer) attempting to visualize the ventricular and aortic edges of the prosthesis

The Crucial Role of 3DE



- Immediately after deployment of the prosthetic valve, the presence of perivalvular aortic regurgitation is assessed. It is important for the sonographer to display the aortic regurgitation using the biplane method with color in the long-axis view to distinguish between transvalvular and perivalvular jets. While assessment for perivalvular aortic regurgitation can be performed prior to catheter removal.

Low Flow Aortic Stenosis

- Aortic stenosis is the 3 rd most common CV disease after HTN and CAD (in western world)
- Prevalence is 2-7% over the age of 65 years
- Evaluation of aortic stenosis is the most challenging of all valvular heart diseases

Stewart BF, Siscovick D, Lind BK, et al. Clinical factors associated with calcific aortic valve disease. Cardiovascular Health Study. J Am Coll Cardiol 1997; 29:630–634.

Aortic Stenosis

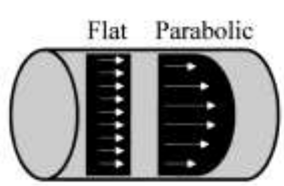
Indicator	Mild	Moderate	Severe
Jet velocity (m/s)	Less than 3.0	3.0-4.0	Greater than 4.0
Mean gradient (mm Hg)*	Less than 25	25-40	Greater than 40
Valve area (cm^2)	Greater than 1.5	1.0-1.5	Less than 1.0
Valve area index (cm^2/m^2)			Less than 0.6

GRADIENT = FLOW DEPENDENT VARIABLE

Gradient calculation- $\Delta PG = 4.V^2$

Small reduction in flow can cause great reductions in gradient

Flow Diagram



Flow = CSA x Velocity

MISMATCH BETWEEN GRADIENTS AND VALVE AREA

Aortic Stenosis

Indicator	Mild	Moderate	Severe
Jet velocity (m/s)	Less than 3.0	3.0-4.0	Greater than 4.0
Mean gradient (mm Hg)*	Less than 25	25-40	Greater than 40
Valve area (cm^2)	Greater than 1.5	1.0-1.5	Less than 1.0
Valve area index (cm^2/m^2)			Less than 0.6

1. INDEXING TO BSA
2. INACCURACY IN CALCULATION OF LVOT DIAMETER
3. WHO SAID AVA < 1.0 CORRESPONDS TO GRADIENTS > 40 ???
4. LOW FLOW STATE **(DEFINED SVI <35 ml/mt²)**

Aortic Stenosis

Indicator	Mild	Moderate	Severe
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Valve area index (cm^2/m^2)			Less than 0.6

- INDEXING TO BSA

Eg: AVA of 0.9 cm2, BSA=1.3, iAVA= 0.7 cm^2/m^2

AVA of 1.2 cm2, BSA=2.1, iAVA= 0.57 cm^2/m^2

Case Scenario

- H/O

72 yr old Man

HTN, Dyslipidemia, CAD

- C/O

DOE & AOE CLASS II

- AV GRADIENTS=43/28
- LVEF= 32 %
- iAVA= 0.5 cm^2

Case Scenario

- H/O

72 yr old Man

HTN, Dyslipidemia,

CAD

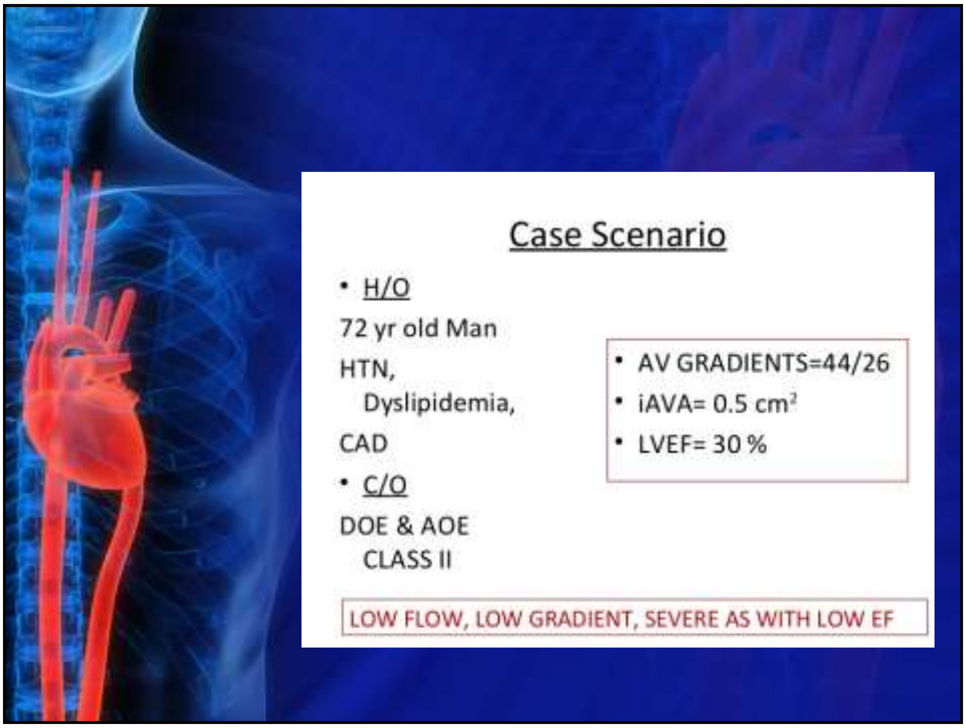
- C/O

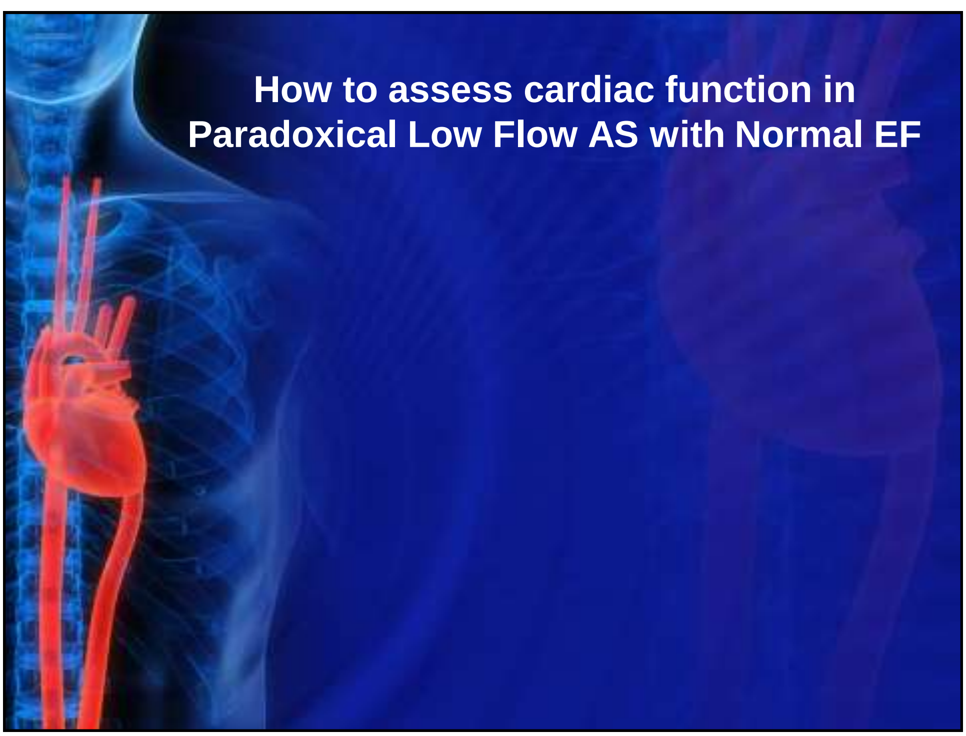
DOE & AOE CLASS II

- AV GRADIENTS=43/28
- LVEF= 52 %
- iAVA= 0.5 cm^2

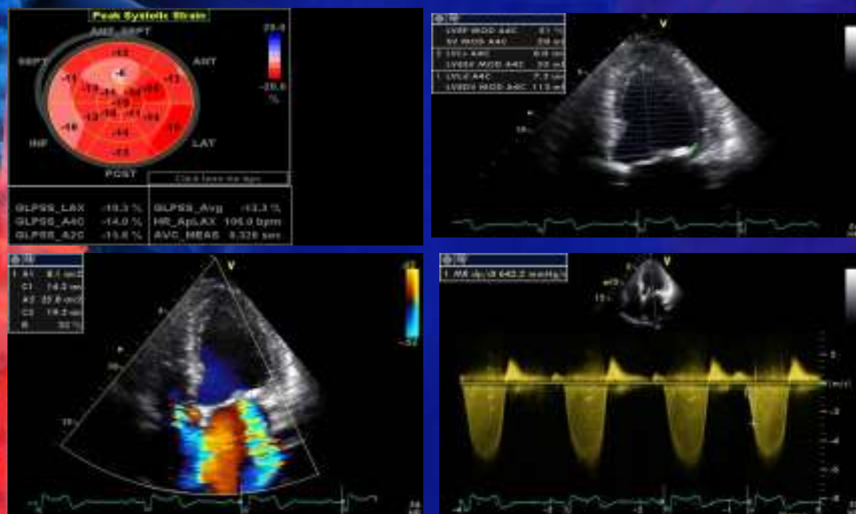
Causes of low flow state

- Till 2007→ low flow due to LOW EF
- NOW→ low flow can also be secondary to Preserved EF
  “new entity”→ Paradoxical Low flow AS


Case Scenario
• H/O
72 yr old Man
HTN,
Dyslipidemia,
CAD
• C/O
DOE & AOE
CLASS II
• AV GRADIENTS=44/26
• iAVA= 0.5 cm²
• LVEF= 30 %
LOW FLOW, LOW GRADIENT, SEVERE AS WITH LOW EF

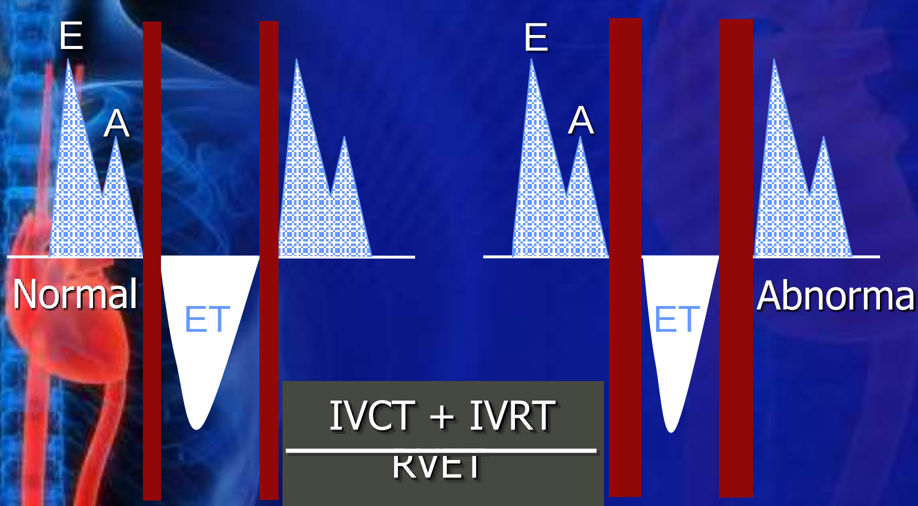

How to assess cardiac function in
Paradoxical Low Flow AS with Normal EF

Bulls eye technique (automated function imaging algorithm) generated from apical 2,3 & 4 chamber views illustrated the impaired global longitudinal peak systolic strain (GLPSS) of -13% in patient with significant mitral incompetence but normal ejection fraction (EF = 51%) , note that : MR+dp/dt = 645mmhg/s only



Galal Elkilany et al

Index of Myocardial Performance (RIMP)



Normal 0.28 ± 0.04

PATHOPHYSIOLOGY

LOW-LVEF "CLASSICAL" LOW-FLOW, LOW-GRADIENT AS

- LOW FLOW secondary to LOW EF
- LOW EF is due to myocardial dysfunction

"whether this myocardial dysfunction is
-secondary to AS
-secondary to other causes, or
-primary myocardial disease, needs to be evaluated"

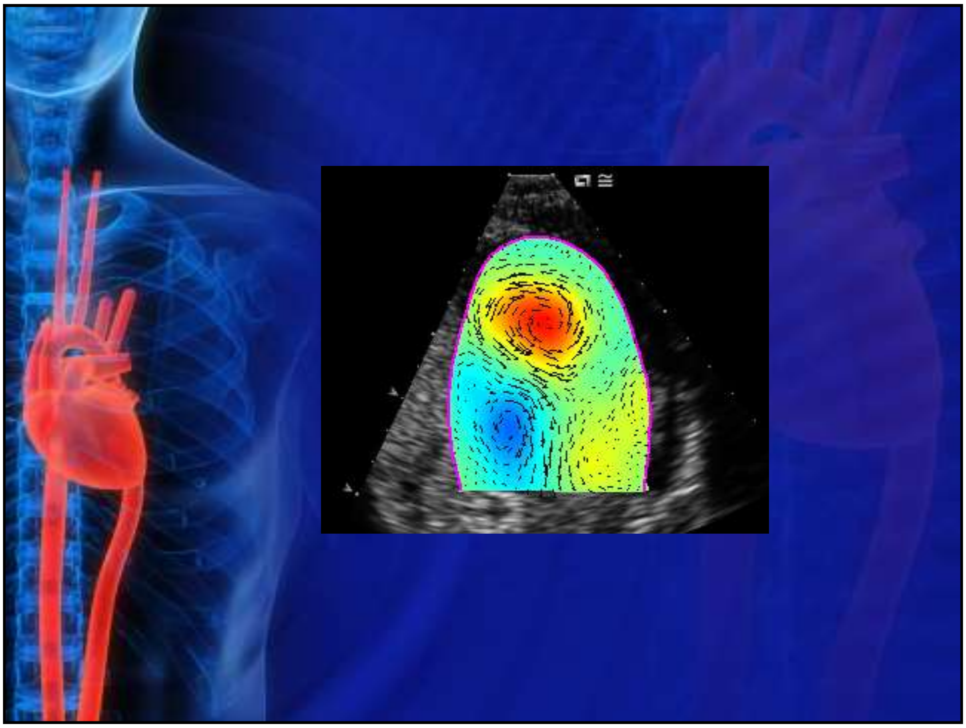
MYOCARDIAL DYSFUNCTION SECONDARY TO CAUSES OTHER THAN AS

-DILATED CARDIOMYOPATHIES (1⁰ MYOCARDIAL DYFUNCTION)

-ISCHEMIC HEART DISEASE

-HTN HEART DISEASE (AFTER LOAD MISMATCH)

In all these patients, AVA was misjudged as <1.0 due to incomplete opening of AV due to low EF and → labelled as "PSEUDO SEVERE AS"



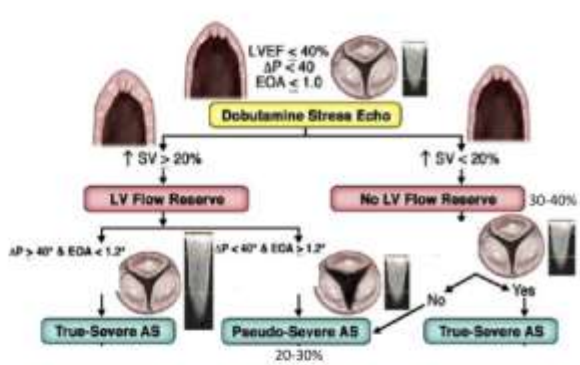
MYOCARDIAL DYSFUNCTION SECONDARY TO AS

- " True severe AS"
- Removal of the only afterload-AS can lead to dramatic improvements in patients' symtoms/survival compared to medical therapy alone

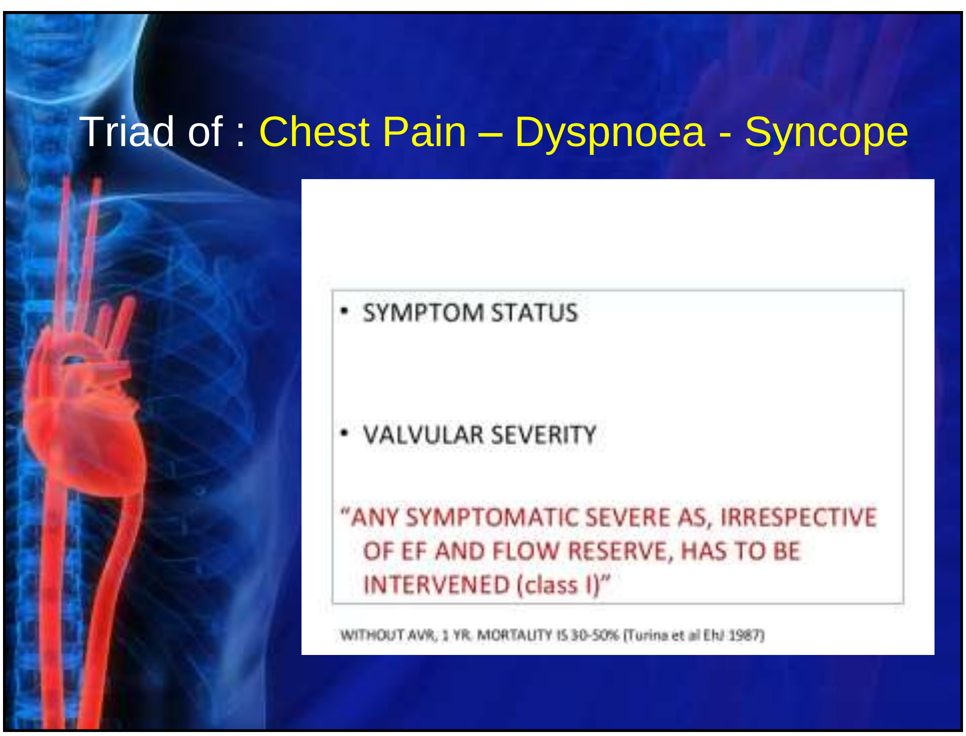
DIAGNOSIS

- FIRST SUSPICION→ GRADIENT-AVA MISMATCH during routine echo
- GRADIENT < 40 mmhg, AVA <1.0, EF <40 %
- Dobutamine stress echo (exercise stress echo)

Class IIA recommendation



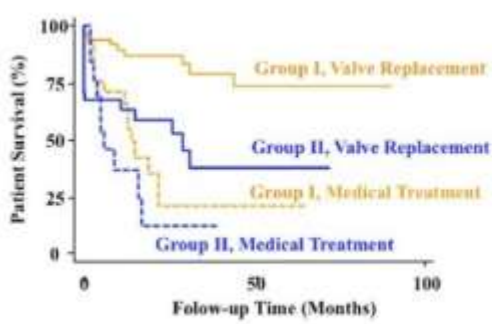

Treatment Decisions


Triad of : Chest Pain – Dyspnoea - Syncope
• SYMPTOM STATUS
• VALVULAR SEVERITY
"ANY SYMPTOMATIC SEVERE AS, IRRESPECTIVE OF EF AND FLOW RESERVE, HAS TO BE INTERVENED (class I)"
WITHOUT AVR, 1 YR. MORTALITY IS 30-50% (Turina et al EhJ 1987)

Severe 'Asymptomatic' AS WITH LOW EF

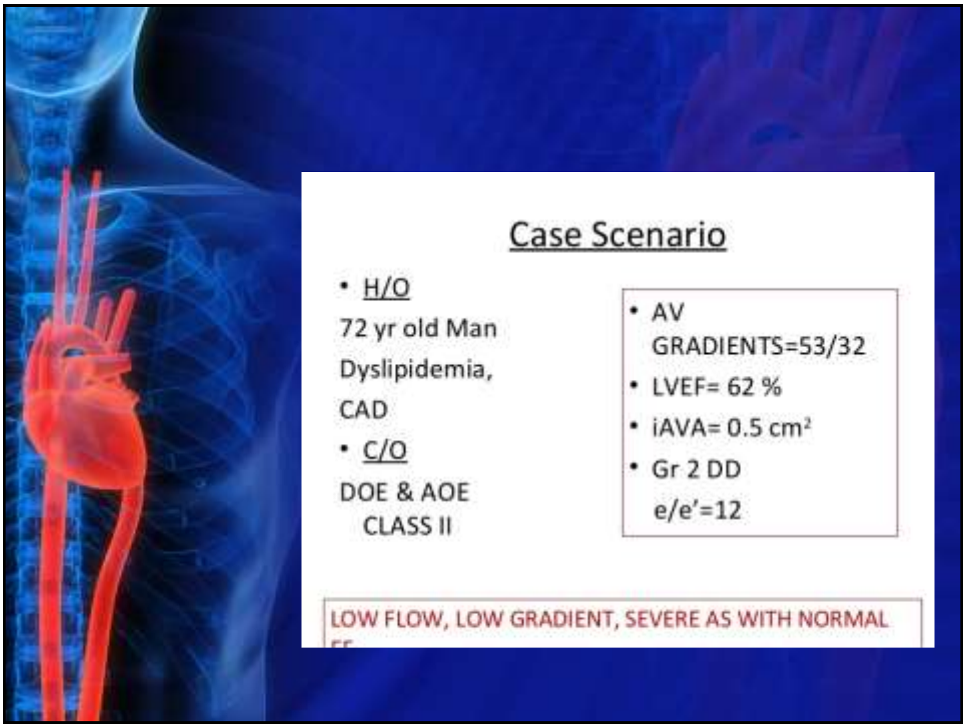
Recommendation:
AVR for patients who have no symptoms and whose left ventricular ejection fraction is less than 50% (class I indication, level of evidence C)

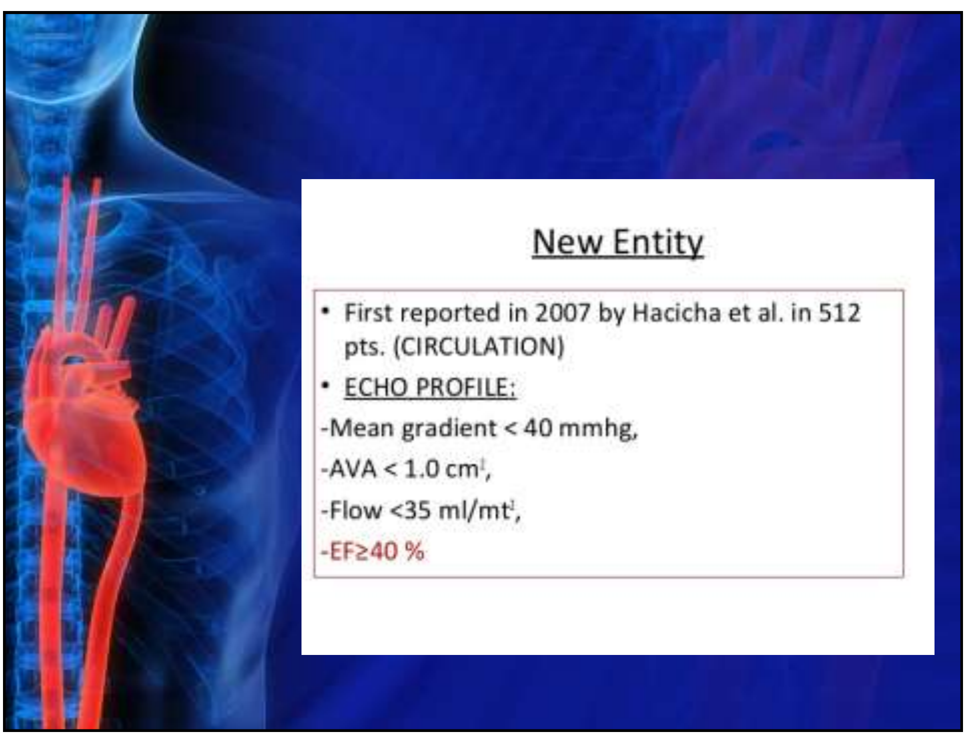
- WITH NORMAL EF-management is challenging, an abnormal response to exercise stress testing and elevated BNP may identify a higher-risk group that might benefit from closer followup and earlier surgery

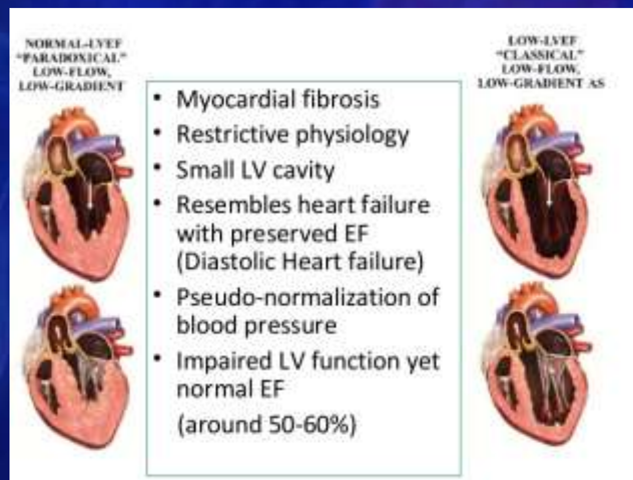


Group I= Flow reserve +

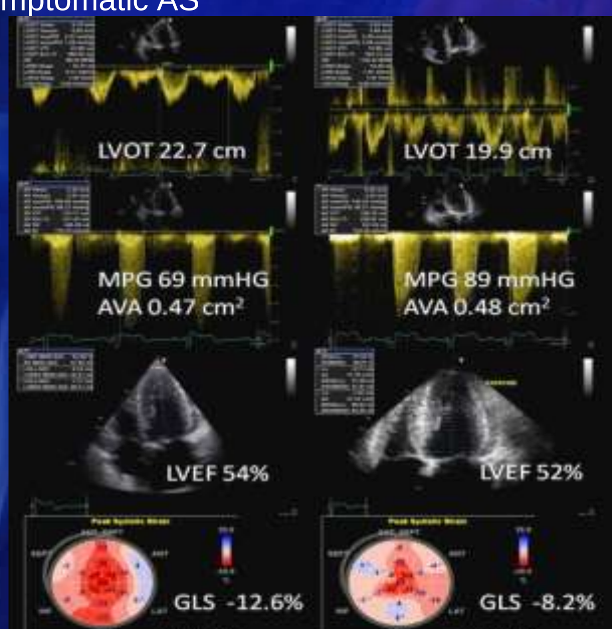
Group II= Flow reserve -


Case Scenario
• H/O
72 yr old Man
Dyslipidemia,
CAD
• C/O
DOE & AOE
CLASS II
• AV
GRADIENTS=53/32
• LVEF= 62 %
• iAVA= 0.5 cm^2
• Gr 2 DD
e/e'=12
LOW FLOW, LOW GRADIENT, SEVERE AS WITH NORMAL


New Entity
• First reported in 2007 by Hacicha et al. in 512 pts. (CIRCULATION)
• ECHO PROFILE:
-Mean gradient < 40 mmhg,
-AVA < 1.0 cm^2,
-Flow <35 ml/mt^2,
-EF≥40 %



ROLE OF STRESS ECHO AND STRAIN in A symptomatic AS



"Normal LVEF Does Not Mean Normal Myocardial Function"

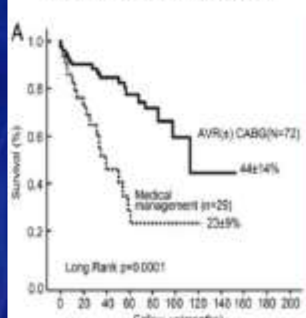
- LVEF is a late and insensitive marker for study of LV functions
- Not too far that LVEF will be replaced by other better markers of LV function

ALTERNATIVES TO 'EF'

- Valvulo-Arterial Impedance (Zva) >5.5
- MPI (Tei Index) >0.42
- Mitral annular displacement (By TDI) < 12 mm
- Global LV Strain < 10%
- CT AV Calcium Scoring >1650 AU
- BNP levels >550 pg/ml

TREATMENT DECISIONS

LOW FLOW, NORMAL EF, SEVERE AS



- 2012 ESC guidelines class IIa indication for AVR
- "This subgroup of patients seems to be at a more advanced stage and has a poorer prognosis if treated medically rather than surgically"
- It remains to be determined if TAVI could not be a better alternative in these patients

Tarantini G, Covolo E, Razzolini R, et al.
The Annals of Thoracic Surgery, Volume 91(6)

Conclusions

2D and 3D TEE play a central role during TAVR procedures :

- Pre Procedure: – Characterization of aortic complex , determination of AS severity, identification of contraindications
- Intra Procedure: – Catheter and device guidance, AVR deployment
- Post Procedure – Valve position stability and function, AI, complications

Conclusion

- ACCURATE AVA CALCULATION BY CONTINUITY EQUATION MUST BE A STANDARD IN EVALUATION OF A.S BY ECHO
- ELSE WE ARE GOING TO MISS 30 % CASES OF SEVERE AS
- LOW FLOW AS COULD BE DUE TO BOTH NORMAL AND REDUCED EF
- INSTITUTION PROTOCOLS TO BE DESIGNED FOR EVALUATION AND TREATMENT OF LOW FLOW STATES

LOW-LVEF
"CLASSICAL"
LOW-FLOW,
LOW-GRADIENT AS

- Low Flow due to low EF
- DSE to differentiate True from Pseudo Severe AS
- EOA (proj) & CT AV Ca Score
- AVR irrespective of EF and Flow reserve

NORMAL-LVEF
"PARADOXICAL"
LOW-FLOW,
LOW-GRADIENT

- Low Flow due to intrinsic myocardial dysfunction
- Better picked up by novel methods of LV function like MAD, Tei index, Strain apart from Zva, BNP levels
- AVR better than medical management

Good Morning SMS

Simplified Statement

"Irrespective of AV Gradients and LVEF, symptomatic patients with iAVA < 0.6 cm^2, and CT AV calcium score > 1650 AU, should be referred for AVR"

- In 2018, there is a clear trend toward a movement of TAVR out of hybrid operating rooms and into catheterization laboratories.
- Without question, patients undergoing TAVR are still at risk for procedural complications, and as such an anesthesiologist should remain part of the TAVR team.
- Computed tomography predicts complications,
- TEE continues to play a vital role.


Thank You