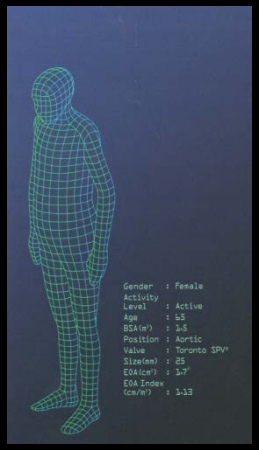

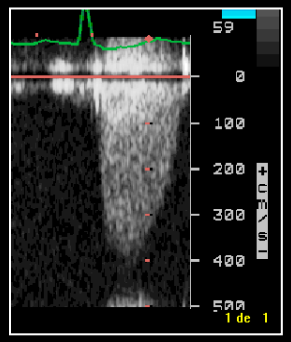

EuroValves 2015, Nice

Prosthesis-Patient Mismatch or Prosthetic Valve Stenosis?

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DE QUÉBEC

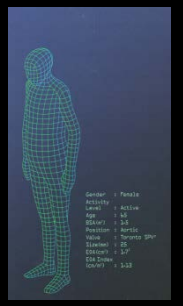
Université
LAVAL

Disclosure Statement

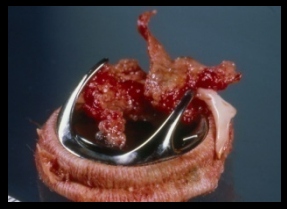
- **Edwards Life Science: Research grant for Echo Core Lab, transcatheter** aortic and mitral **valve replacement**

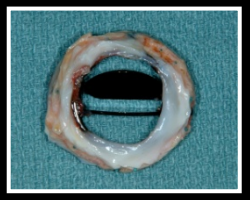
- **V Wave Ltd.**

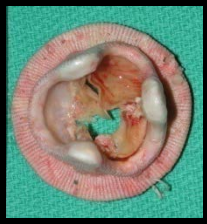
Etiology of High Doppler Gradients in Prosthetic Heart Valves



- **Prosthesis-patient mismatch i.e. too small a prosthesis in too large a patient**
- **Prosthesis dysfunction due to an acute (e.g. thrombus) , subacute (e.g. endocarditis) or chronic process (e.g. pannus, calcific degeneration in bioprosthesis)**

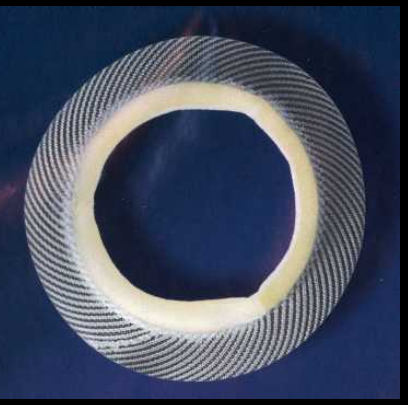




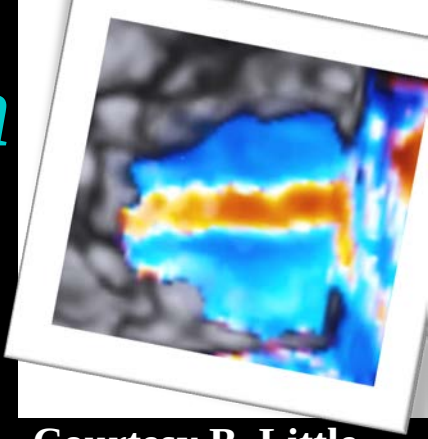


- **Central localized high velocity jet in bileaflet prosthesis**

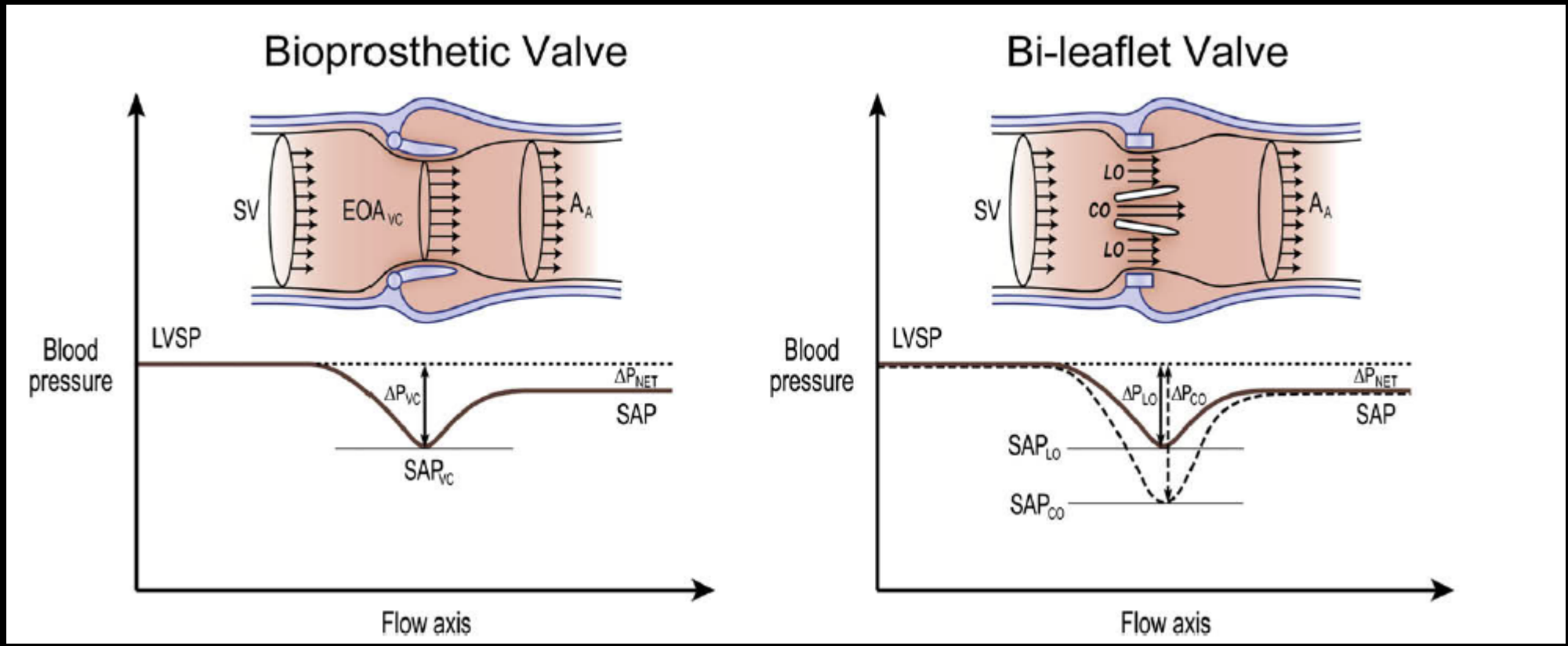
- **Occult mitral prosthesis regurgitation**



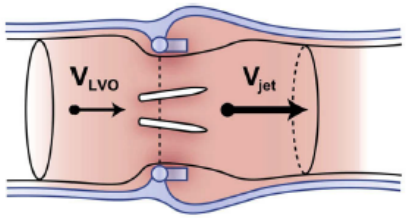
Transvalvular Flow Pattern in Bioprosthesis vs. Mechanical Prosthesis



Courtesy B. Little



Zoghbi et al. J Am Soc Echocardiogr, 22:975-1014, 2009.



$$\text{Doppler Velocity Index} = \frac{\text{Velocity}_{LVO}}{\text{Velocity}_{jet}}$$

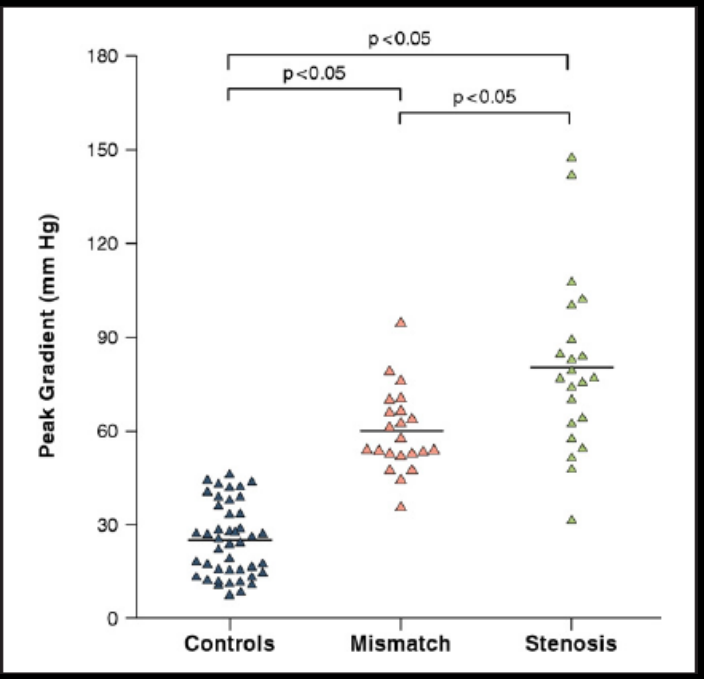
Peak Prosthetic Aortic Jet Velocity > 3 m/s

DVI ≥ 0.30	DVI 0.25 – 0.29	DVI < 0.25
Jet Contour		
AT (ms)		
>100	<100	>100	<100
Consider PrAV stenosis with • Sub-valve narrowing • Underestimated gradient • Improper LVOT velocity*	Normal PrAV	Suggests PrAV Stenosis ϕ	Consider Improper LVOT velocity**
	EOA Index		
	High Flow / PPM		

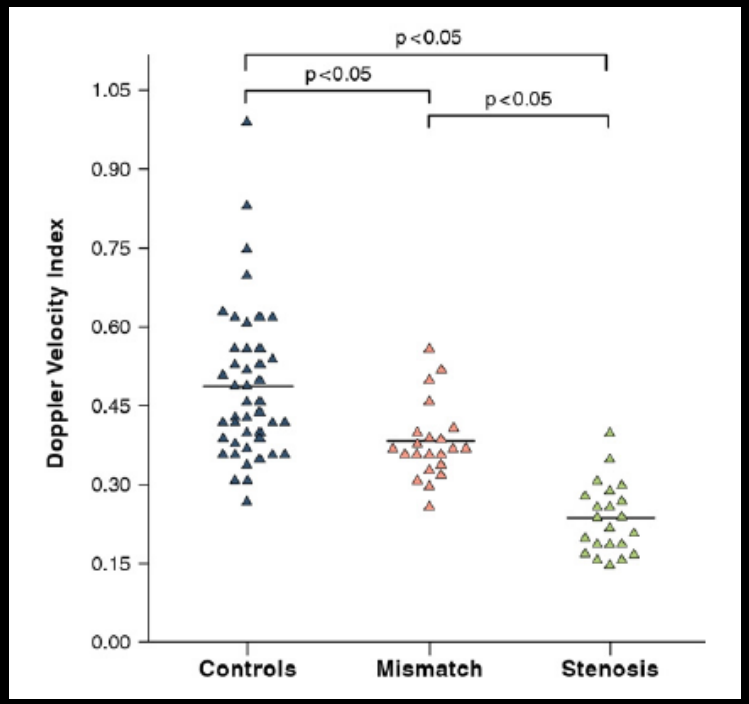
Zoghbi et al.
J Am Soc Echocardiogr, 22:975-1014, 2009.

Gradient, EOA, and DVI for Evaluation of Aortic Prosthetic Valve Function

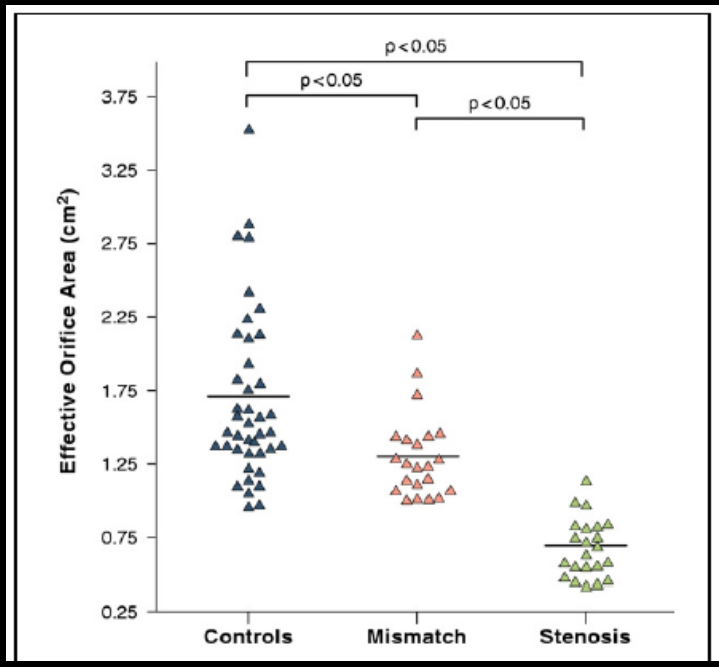
Peak Gradient (mmHg)



DVI

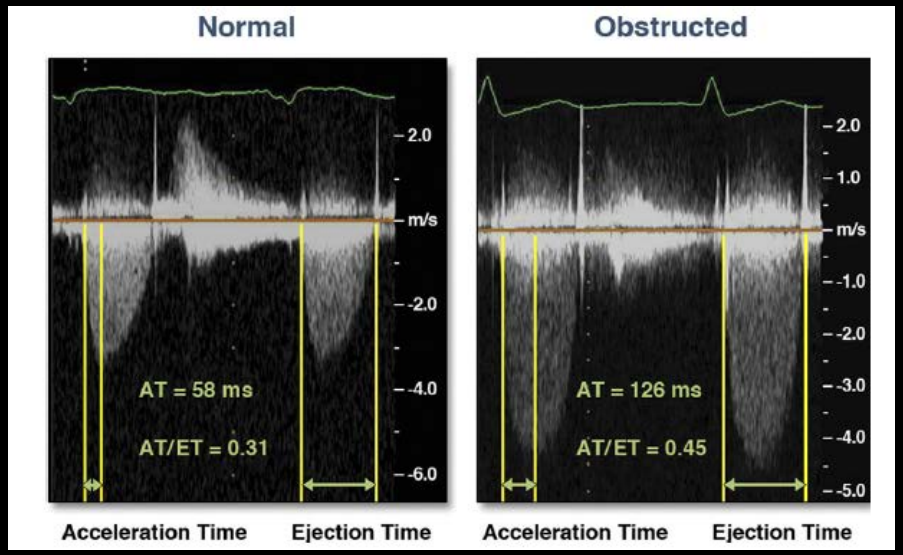


EOA (cm^2)



Zekry et al.
J Am Coll Cardiol Img
2011;4:1161–70

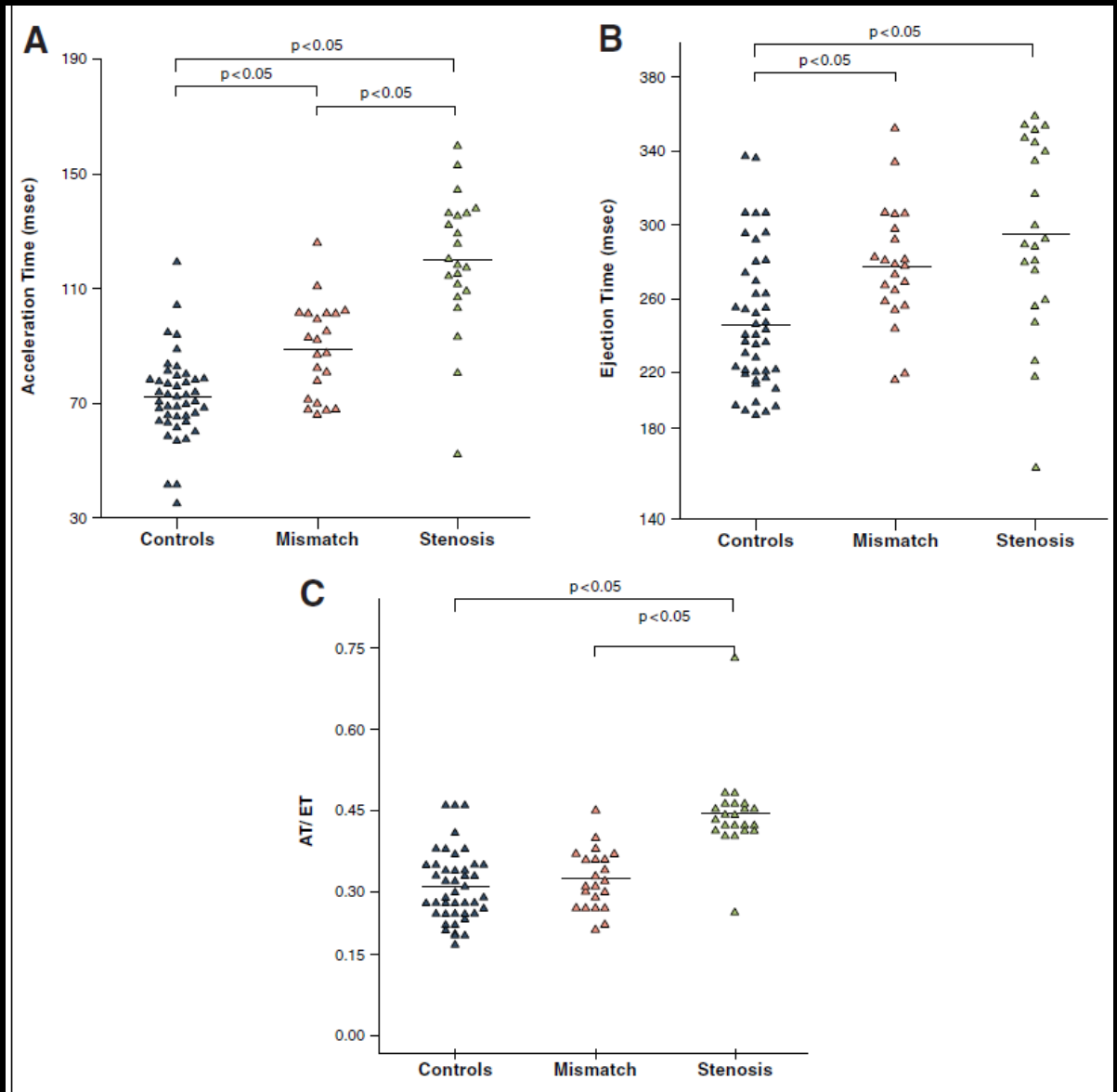
Ratio of Acceleration Time to Ejection Time for Aortic Prosthetic Valve Function



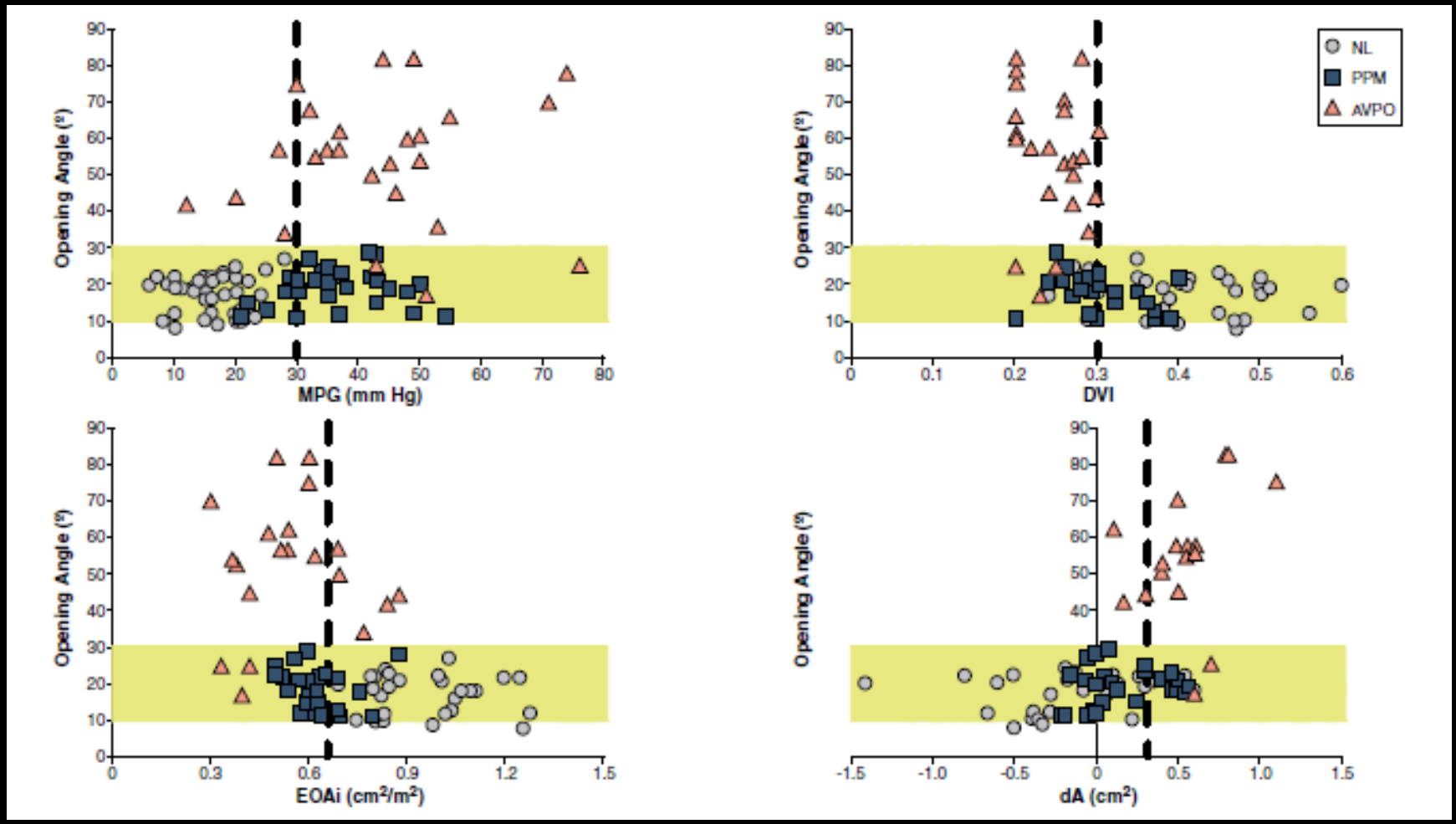
Criteria for PV stenosis:

- AT>100 ms
- AT/LVET>0.37

Zekry et al.
J Am Coll Cardiol Img
2011;4:1161–70



Dysfunction of Bileaflet Aortic Valves: Doppler-Echo vs. Cinefluoroscopy

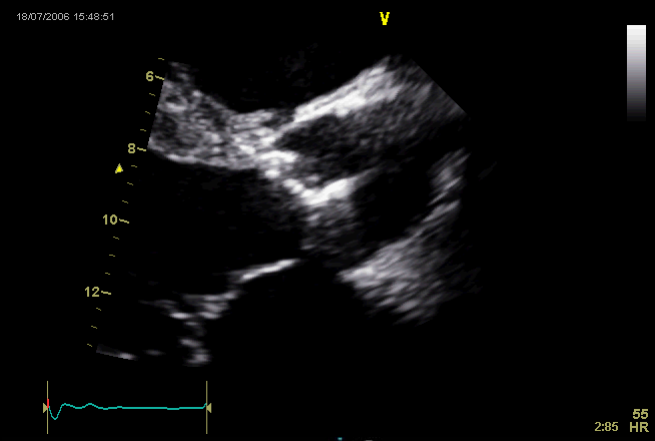


Muratori et al.
JACC Img
2013; 6:196 –205

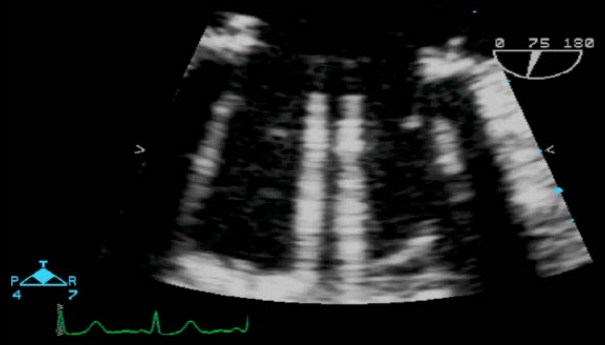
Evaluation of Leaflet Morphology & Mobility: A Cornerstone of Identification of Prosthetic Valve Dysfunction

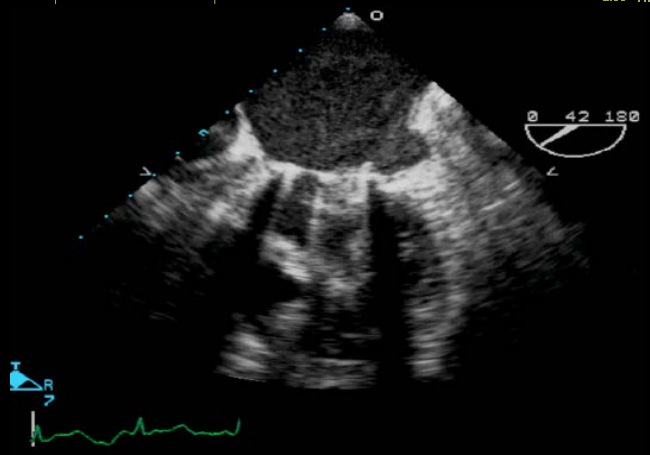
Normal **Abnormal**

Bioprosthesis



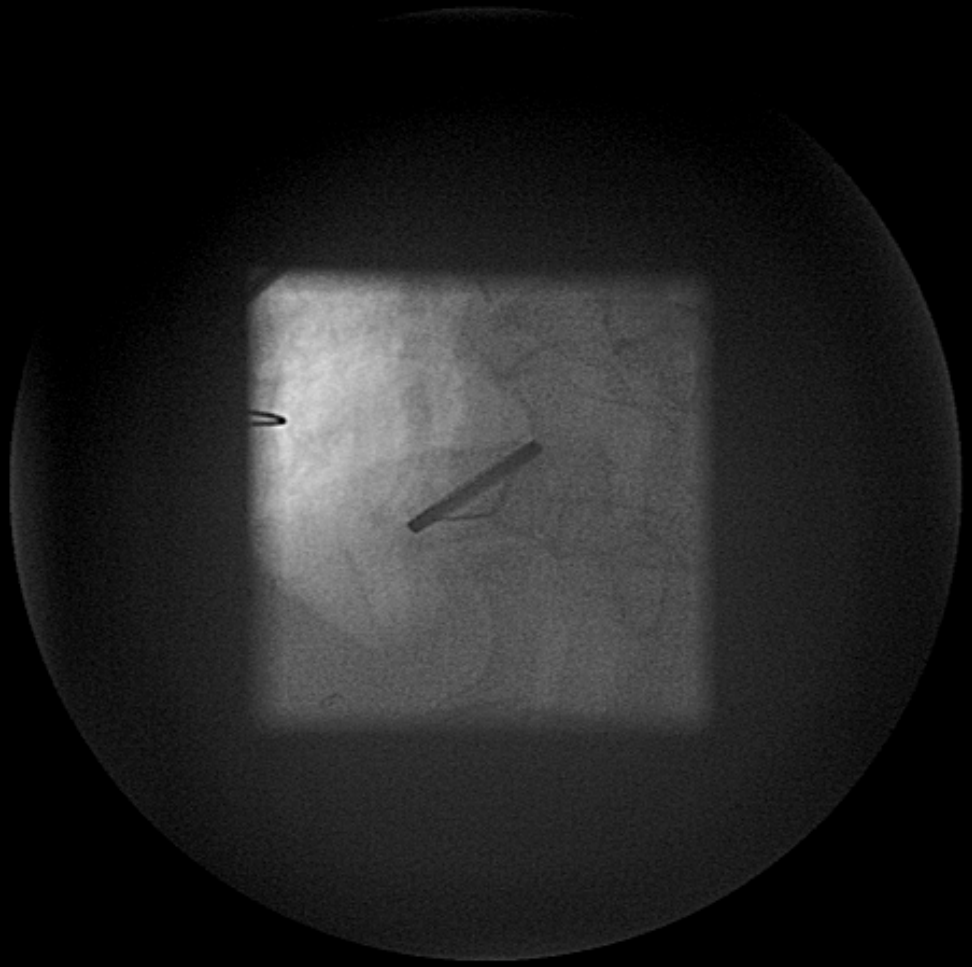
Mechanical



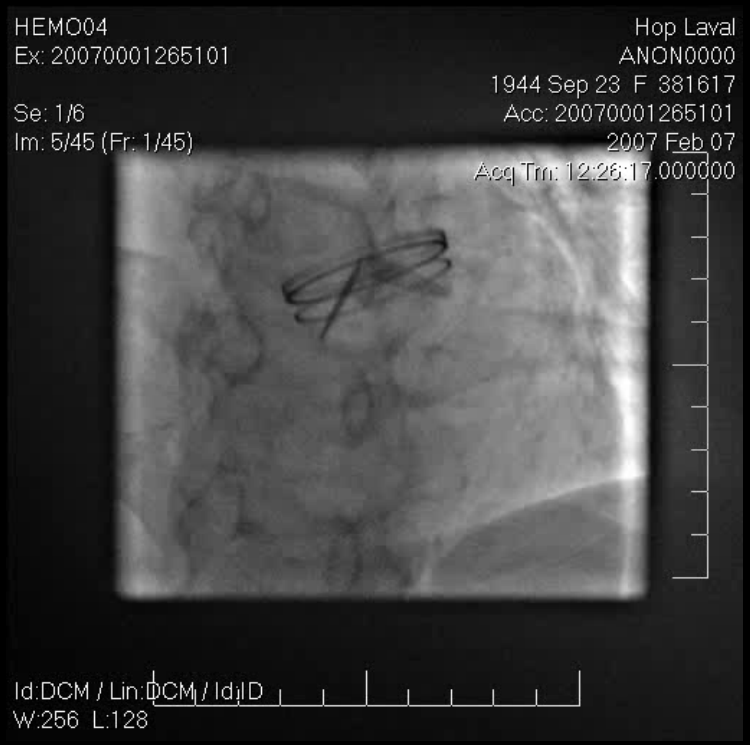


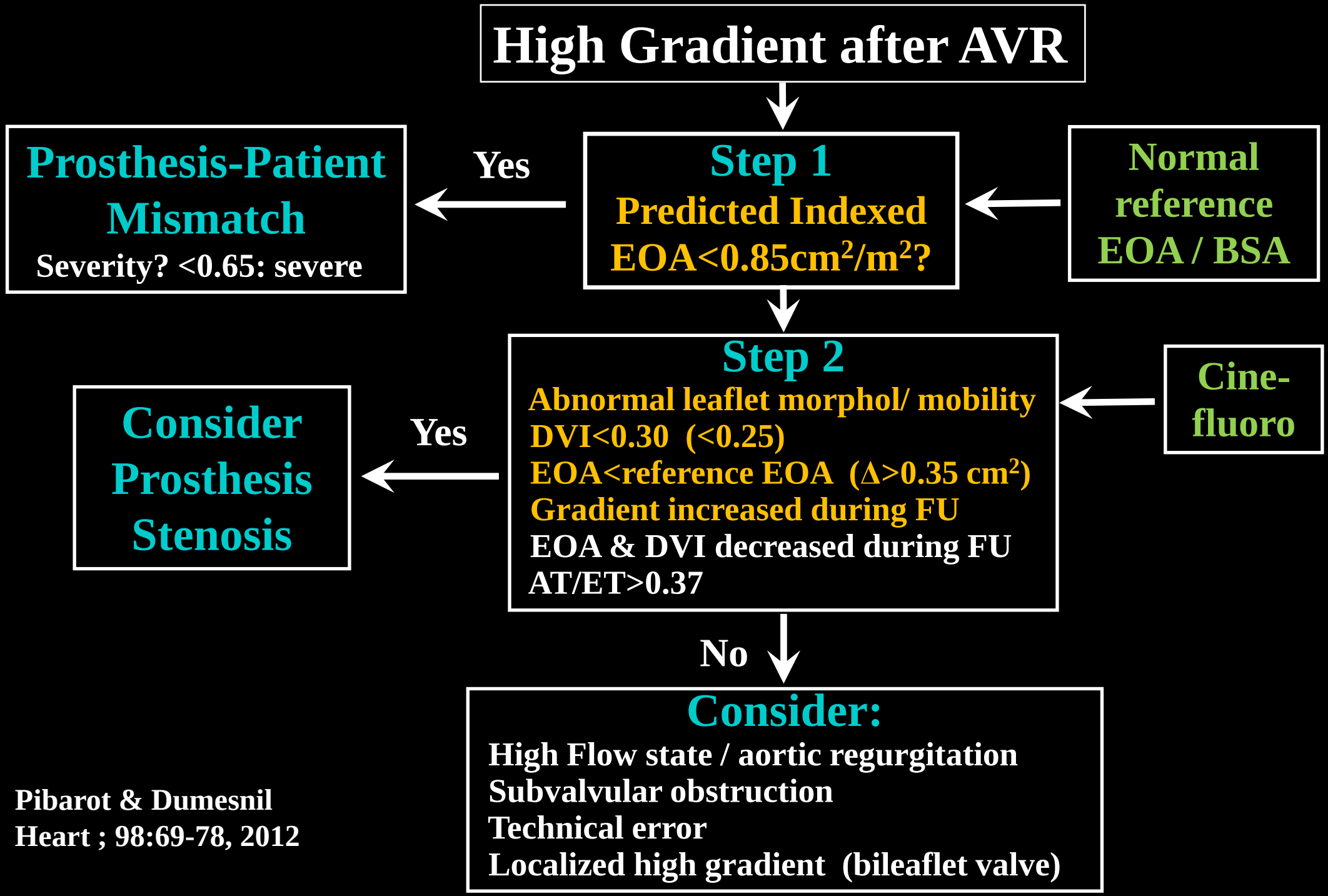
Evaluation of Leaflet Mobility: Usefulness of Cinefluoroscopy in Mechanical Valves

Normal



Abnormal

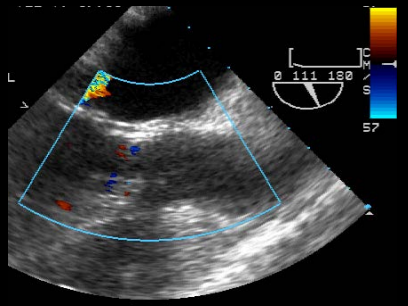




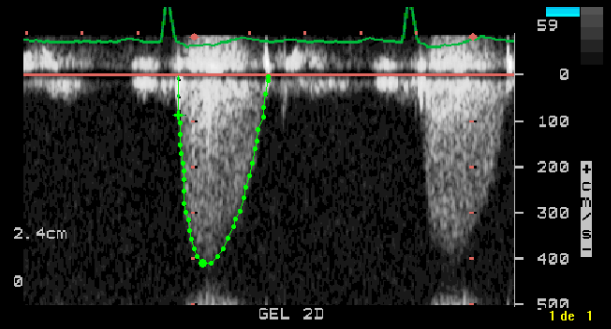
Pibarot & Dumesnil
Heart ; 98:69-78, 2012

Case Study : High Doppler Gradient in Aortic Valve Prosthesis

72 y.o. patient with Carbomedic # 19 aortic prosthesis (3 years) :



- **NYHA class II-III**
- **Moderate diastolic dysfunction**
- **Pulmonary arterial hypertension (systolic PA pressure: 50 mmHg)**



Peak Gradient = 69 mm Hg
Mean Gradient = 40 mmHg

Dumesnil & Pibarot, in Book: Transesophageal Echocardiography Multimedia Manual: 361, 2005

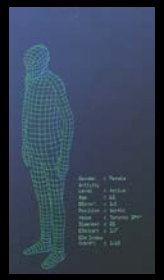
Question no. 1

What is the cause of the high gradient in this patient ?

a. Valve prosthesis dysfunction (thrombus / pannus)?
b. Valve prosthesis-patient mismatch?
c. Central localized high velocity jet?

High Gradient after AVR

Step 1
Predicted Indexed EOA<0.85cm²/m²?



BSA= 1.95 m²

Carbomedics 19 mm

Reference EOA= 1.0 cm²

= 0.51 cm²/m²

Severe Prosthesis-Patient Mismatch!

Table 2 Normal reference values of effective orifice area for the prosthetic valves

Prosthetic aortic valves							
Prosthetic valve size (mm)	**19**	**21**	**23**	**25**	**27**	**29**	**Reference**
Stented bioprosthetic valves							
Mosaic	1.1±0.2	1.2±0.2	1.4±0.3	1.7±0.4	1.8±0.4	2.0±0.4	w8
Hancock II	–	1.2±0.2	1.3±0.2	1.5±0.2	1.6±0.2	1.6±0.2	w8
Carpentier-Edwards Perimount	1.1±0.3	1.3±0.4	1.50±0.4	1.80±0.4	2.1±0.4	2.2±0.4	w8
Carpentier-Edwards Magna	1.3±0.3	1.5±0.3	1.8±0.4	2.1±0.5	–	–	w9, w10
Biocor (Epic)	1.0±0.3	1.2±0.5	1.4±0.5	1.9±0.7	–	–	w11, w12
Mitroflow	1.1±0.2	1.2±0.3	1.4±0.3	1.6±0.3	1.8±0.3	–	w13
Stentless bioprosthetic valves							
Medtronic Freestyle	1.2±0.2	1.4±0.2	1.5±0.3	2.0±0.4	2.3±0.5	–	w8
St Jude Medical Toronto SPV	–	1.3±0.3	1.5±0.5	1.7±0.8	2.1±0.7	2.7±1.0	w8
Mechanical valves							w8
Medtronic-Hall	1.2±0.2	1.3±0.2	–	–	–	–	w8
St Jude Medical Standard	1.0±0.2	1.4±0.2	1.5±0.5	2.1±0.4	2.7±0.6	3.2±0.3	w8
St Jude Medical Regent	1.6±0.4	2.0±0.7	2.2±0.9	2.5±0.9	3.6±1.3	4.4±0.6	w14
MCRI On-X	1.5±0.2	1.7±0.4	2.0±0.6	2.4±0.8	3.2±0.6	3.2±0.6	w15
Carbomedics Standard and Top Hat	1.0±0.4	1.5±0.3	1.7±0.3	2.0±0.4	2.5±0.4	2.6±0.4	w8
ATS Medical*	1.1±0.3	1.6±0.4	1.8±0.5	1.9±0.3	2.3±0.8	–	w16

Pibarot & Dumesnil Heart; 98:69-78, 2012

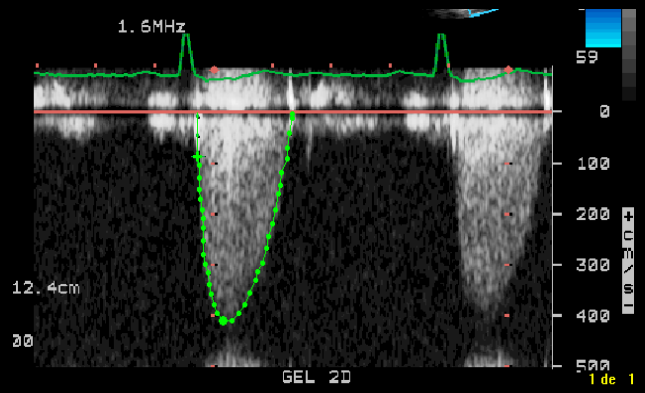
Dumesnil & Pibarot, Curr Cardiol Rev 2011

Question no. 2

Is there any intrinsic dysfunction in addition to prosthesis-patient mismatch?

Case Study : High Doppler Gradient in Aortic Valve Prosthesis

68 y.o. patient
3 Years post AVR
Carbomedic # 19



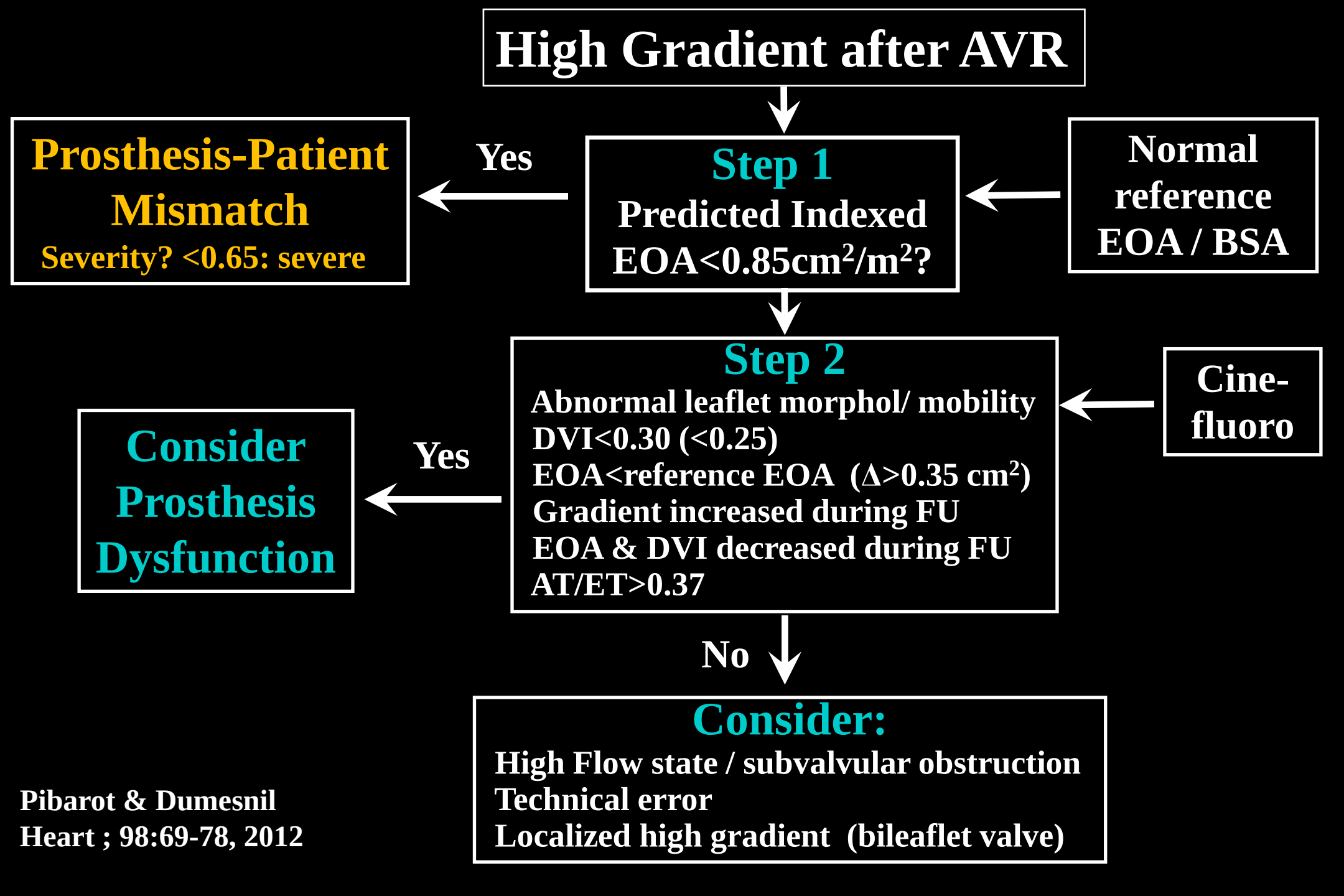
Reference EOA
1.0±0.4

Measured EOA = 1.06 cm^2

BSA = 1.95 m^2

Predicted Indexed EOA: 0.51 cm^2/m^2

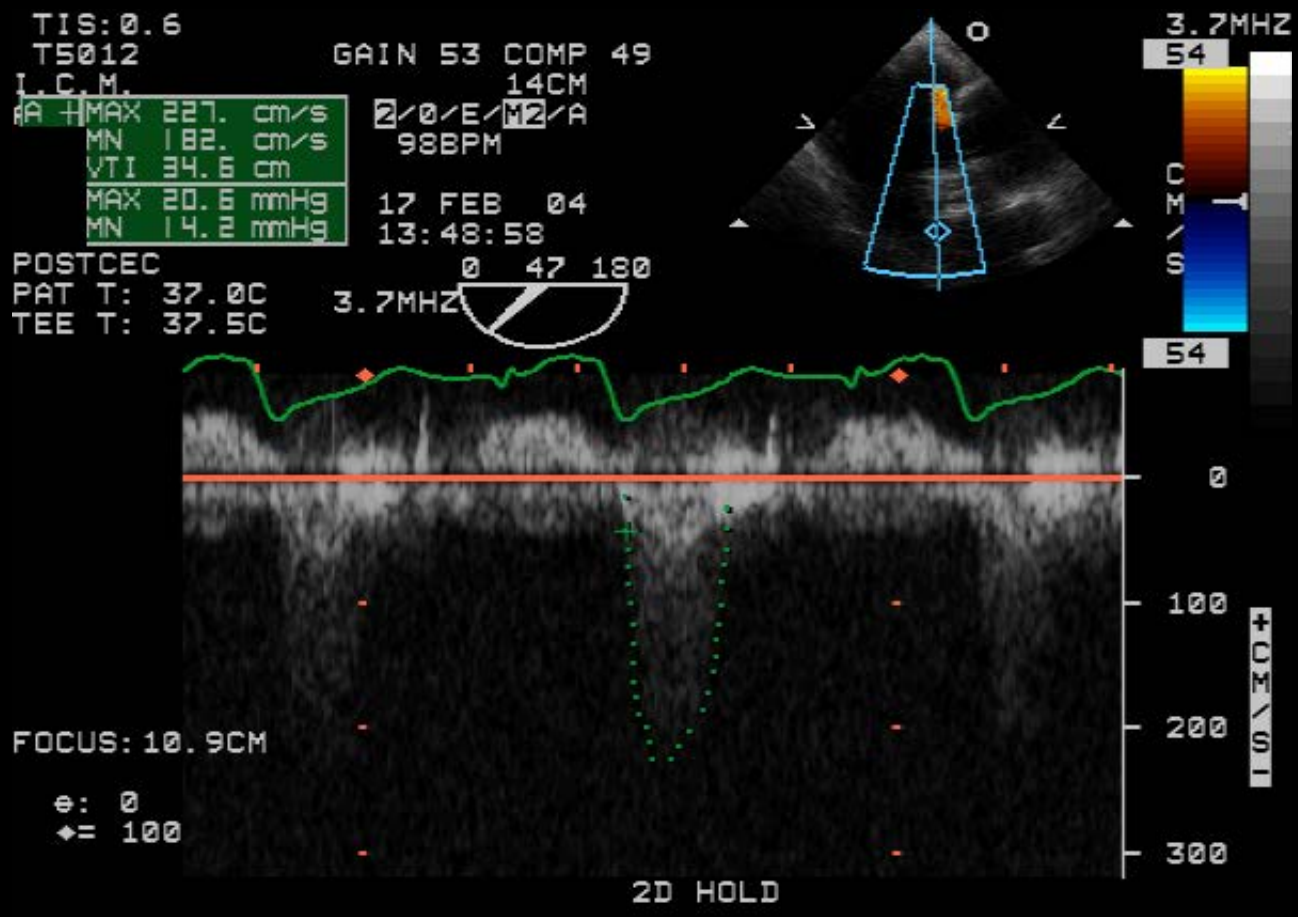
Measured Indexed EOA: 0.55 cm^2/m^2


High Gradient after AVR
Step 1
Predicted Indexed EOA<0.85cm²/m²?
Yes
Prosthesis-Patient Mismatch
Severity? <0.65: severe
Normal reference EOA / BSA
Step 2
Abnormal leaflet morphol/ mobility
DVI<0.30 (<0.25)
EOA<reference EOA (Δ>0.35 cm²)
Gradient increased during FU
EOA & DVI decreased during FU
AT/ET>0.37
Yes
Consider Prosthesis Dysfunction
Cine-fluoro
No
Consider:
High Flow state / subvalvular obstruction
Technical error
Localized high gradient (bileaflet valve)
Pibarot & Dumesnil
Heart ; 98:69-78, 2012

Intraoperative echo after prosthesis implantation

St. Jude Regent # 21
Suprannular
(reference EOA: 2.0 cm^2)

Stroke volume: 64 mL
Heart rate: 98 bpm
Peak gradient: 21 mmHg
Mean gradient: 14 mmHg

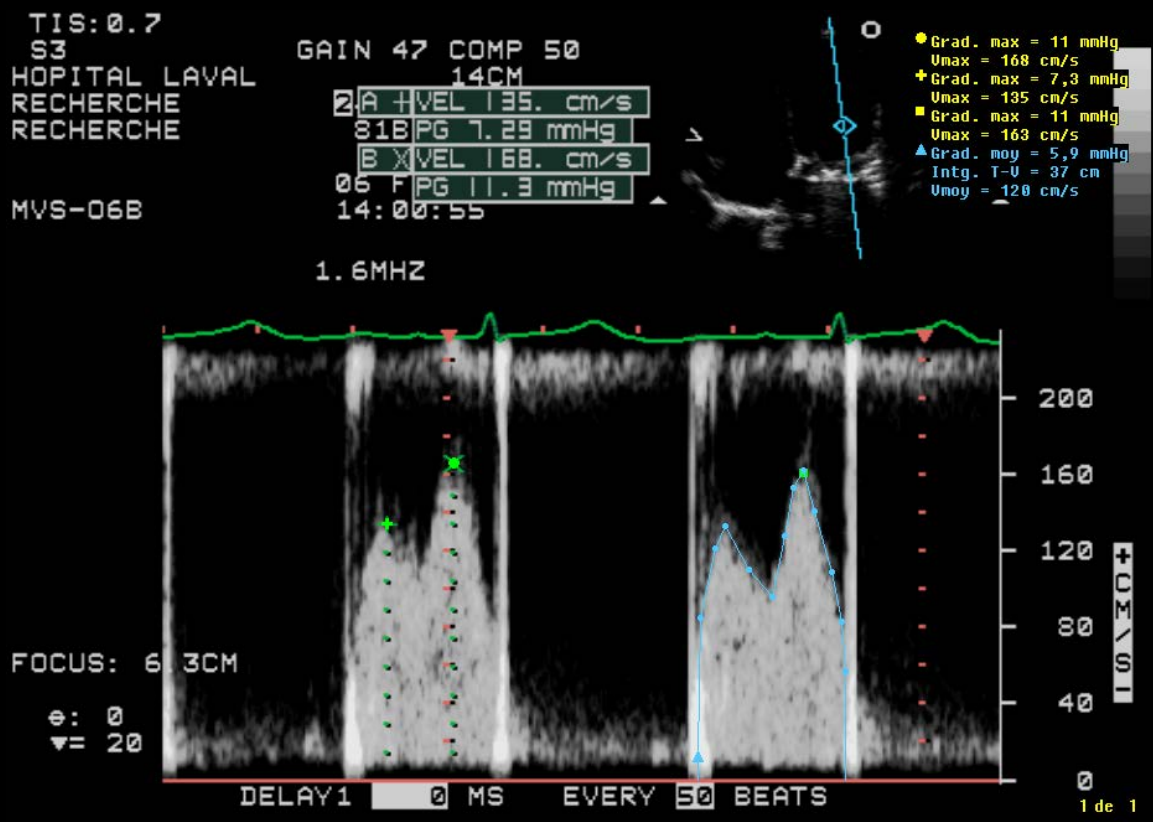


Dumesnil & Pibarot, in Book:
Transesophageal Echocardiography
Multimedia Manual: 361, 2005

Case Study #2

- **62 y.o. woman**
- **BSA: 1.3 m^2**
- **History of Barlow disease**
- **MVR 1 year ago with a MCRI OnX #25 mechanical valve**
- **INR within target since MVR**
- **Asymptomatic**
- **Recruited for a research project**

Echocardiogram



Peak Gradient = 11 mmHg

Mean Gradient = 6 mmHg

DVI : 2.4

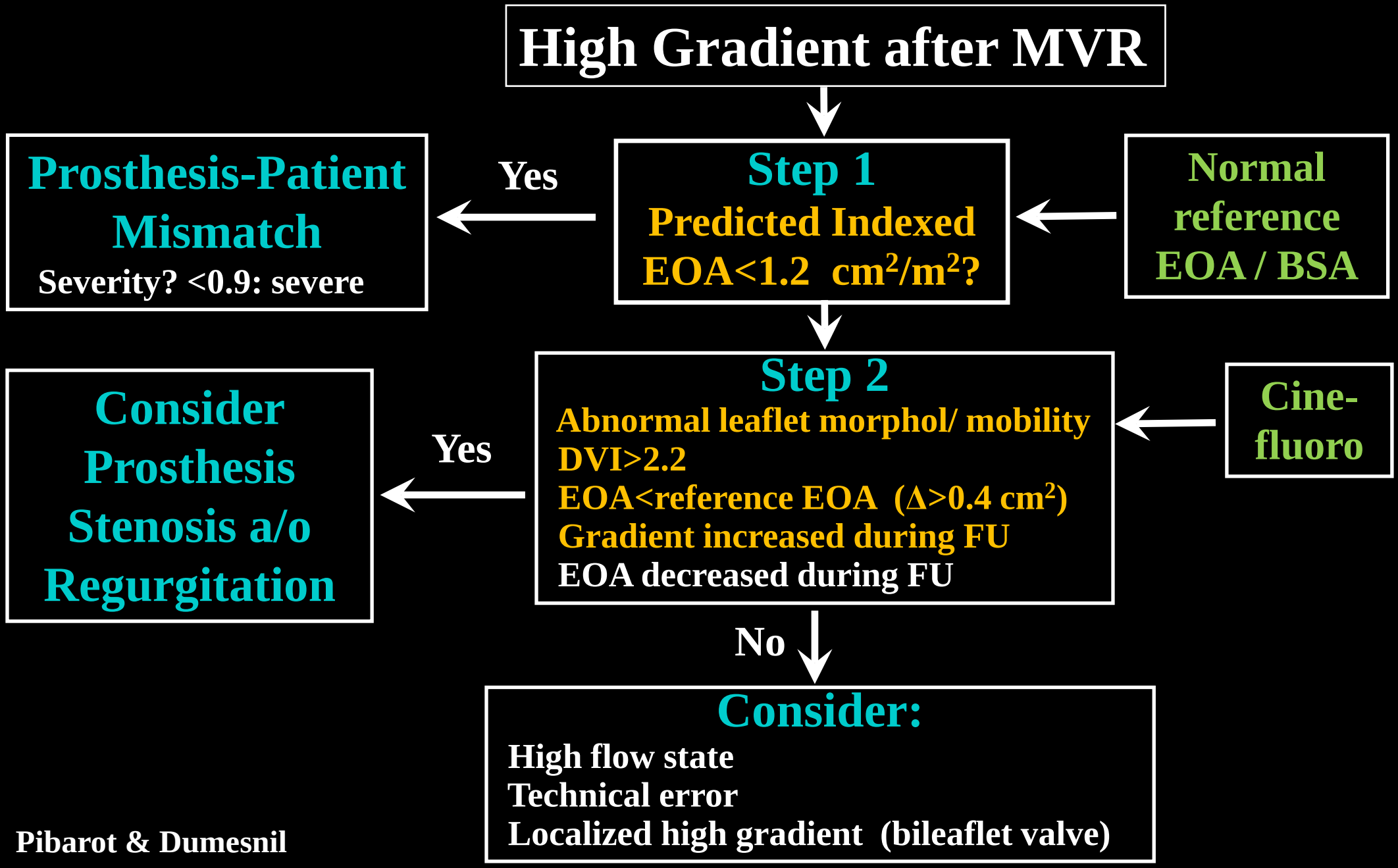
Measured EOA = 1.1 cm^2

Doppler-Echo Evaluation of Mitral Prosthesis - Specifics

- **Doppler Velocity Index: VTI_{mvp} / VTI_{lvot} (>2.2)**
- **EOA calculated using continuity equation as follows : EOA= SV_{lvot} / VTI_{mvp} (Not valid if significant aortic or mitral regurgitation)**
- **Pressure half-time not valid to calculate EOA (grossly overestimates) but may be useful for serial comparisons or if delayed (>130 msec)**

Question no. 1

Is valve prosthesis-patient mismatch a consideration in this case?



Pibarot & Dumesnil
Heart ; 98:69-78, 2012

Normal Reference Values of EOAs for Mitral Prostheses

Table 2. Normal Reference Values of EOAs for the Mitral Prostheses

	Prosthetic Valve Size, mm					
	25 mm	27 mm	29 mm	31 mm	33 mm	Reference
Stented bioprosthesis						
Medtronic Mosaic	1.5±0.4	1.7±0.5	1.9±0.5	1.9±0.5	. . .	15, 28
Hancock II	1.5±0.4	1.8±0.5	1.9±0.5	2.6±0.5	2.6±0.7	29
Carpentier-Edwards Perimount*	1.6±0.4	1.8±0.4	2.1±0.5	. . .	. . .	28
Mechanical prostheses						
St Jude Medical Standard	1.5±0.3	1.7±0.4	1.8±0.4	2.0±0.5	2.0±0.5	28
MCRI On-X†	2.2±0.9	2.2±0.9	2.2±0.9	2.2±0.9	2.2±0.9	28

Pibarot & Dumesnil
Circulation, 119:1034-1048, 2009

Answer: Calculate predicted indexed EOA to exclude PPM

Predicted EOA for OnX #25 → **2.2 cm^2**

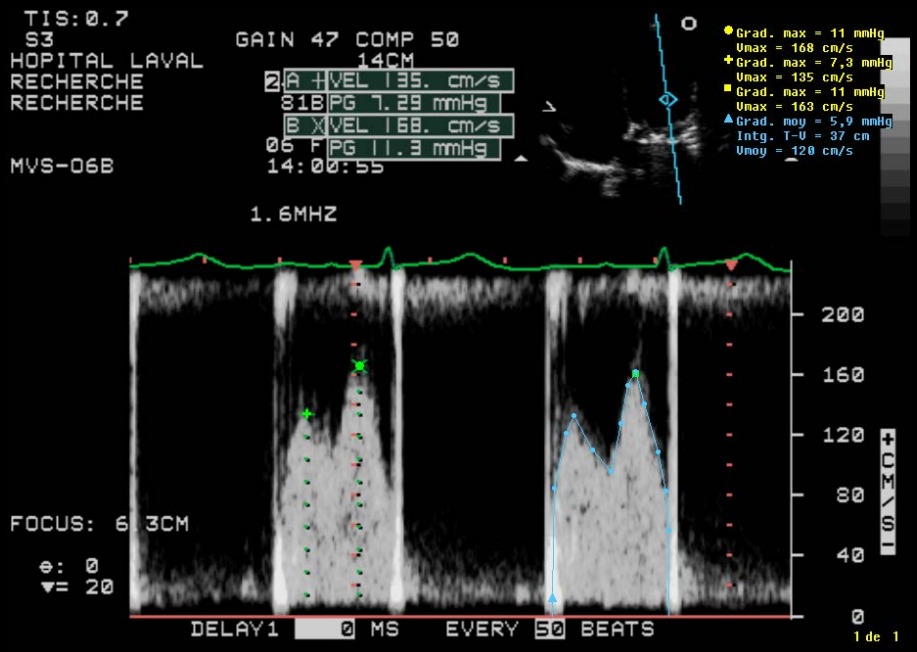
BSA = 1.30 m^2

Predicted Indexed EOA = 1.7 cm^2/m^2

Question no. 2

Should we suspect a prosthesis dysfunction?

Answer : Compare the measured EOA to the normal reference EOA



Measured EOA= 1.1 cm²

Reference value= 2.2 cm²!!

Question no. 3

Differential diagnosis:

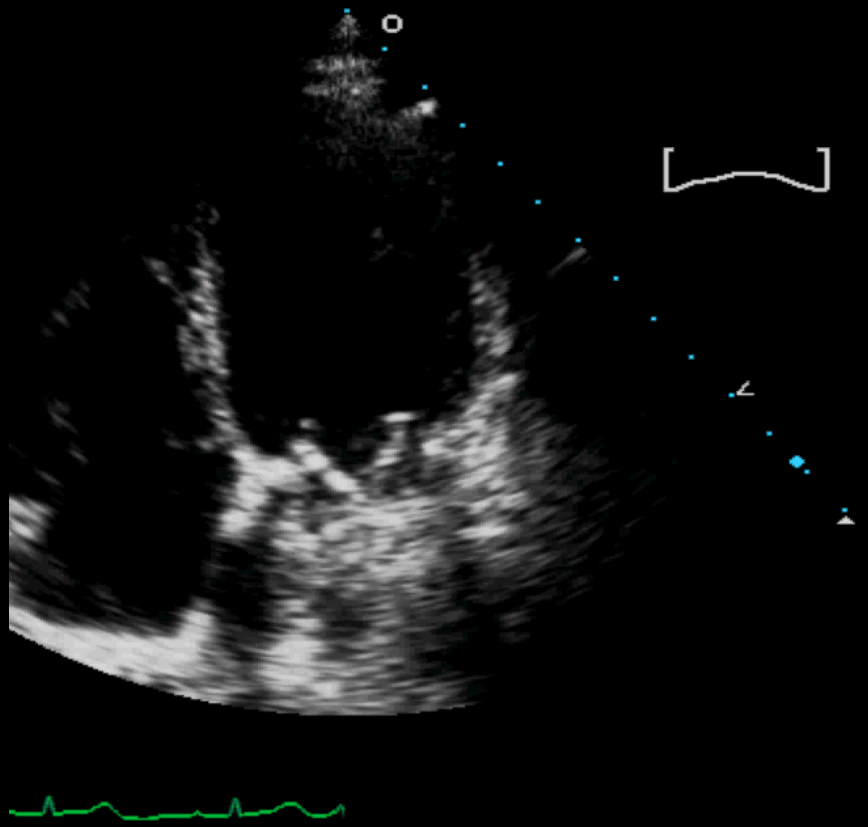
a- Prosthesis dysfunction in this case?

b- Central high velocity jet in bileaflet mechanical prosthesis?

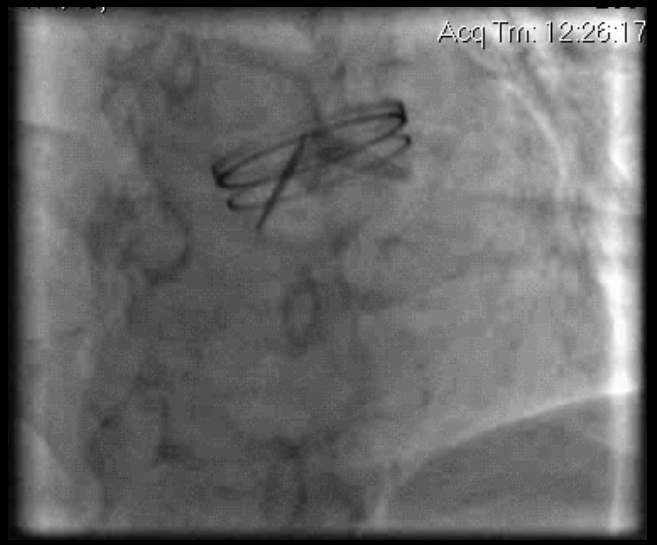
Answer

Evaluate leaflet mobility using either TEE / fluoroscopy / CT

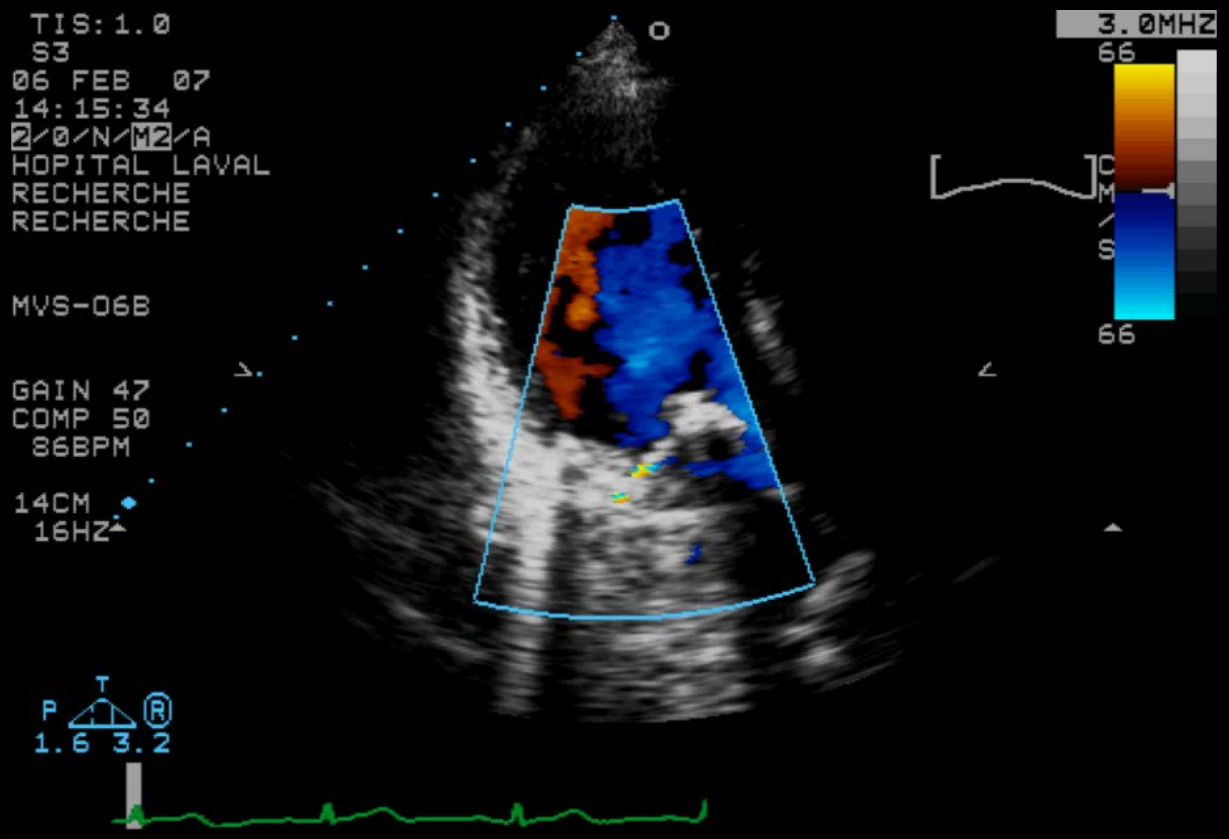
Leaflet Mobility by TTE



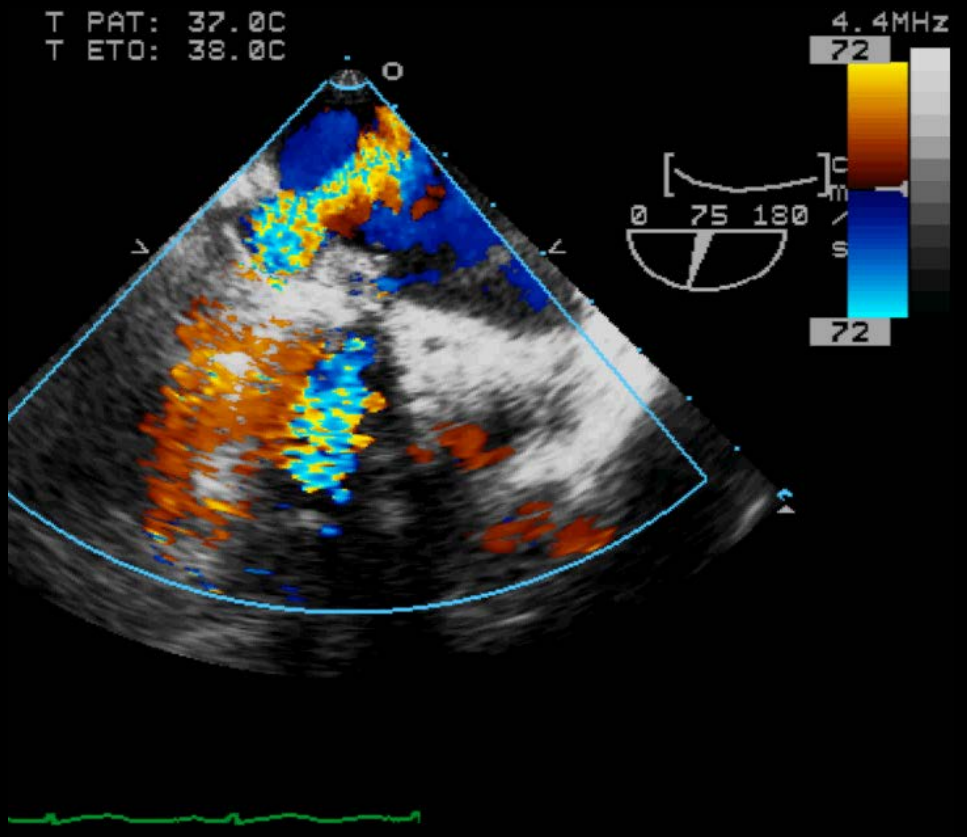
Cinefluoroscopy

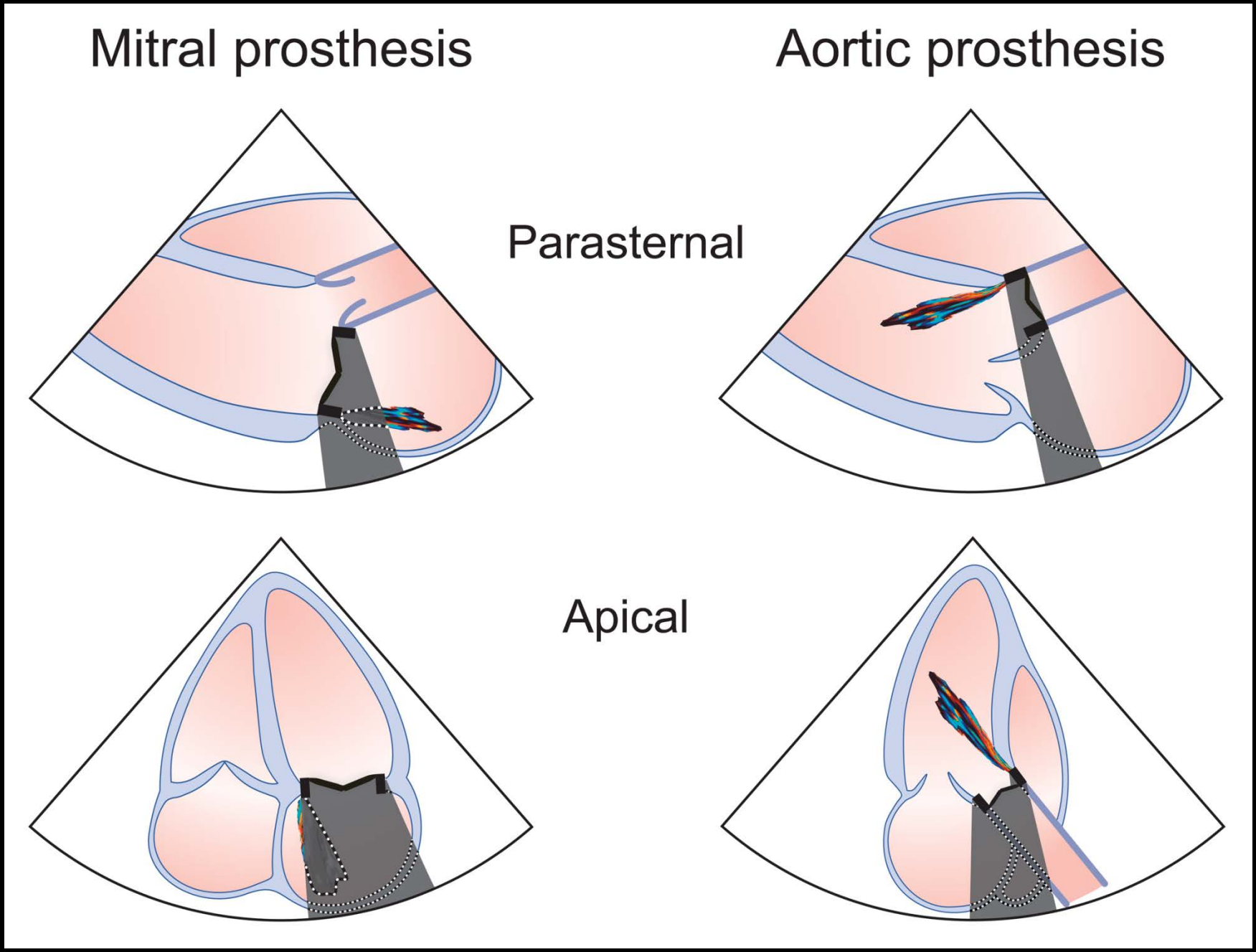


Transthoracic Echocardiogram

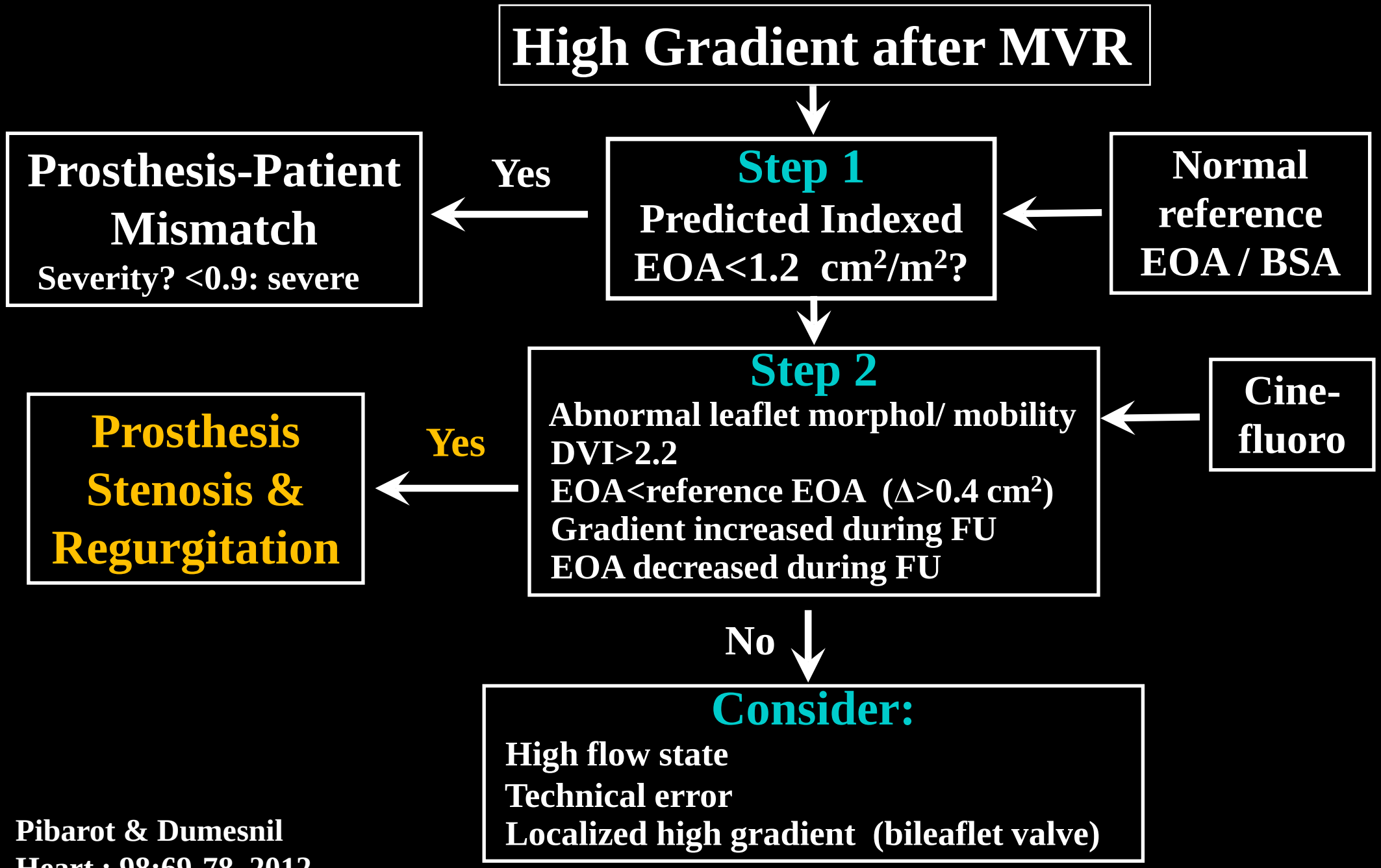


Transesophageal Echocardiogram

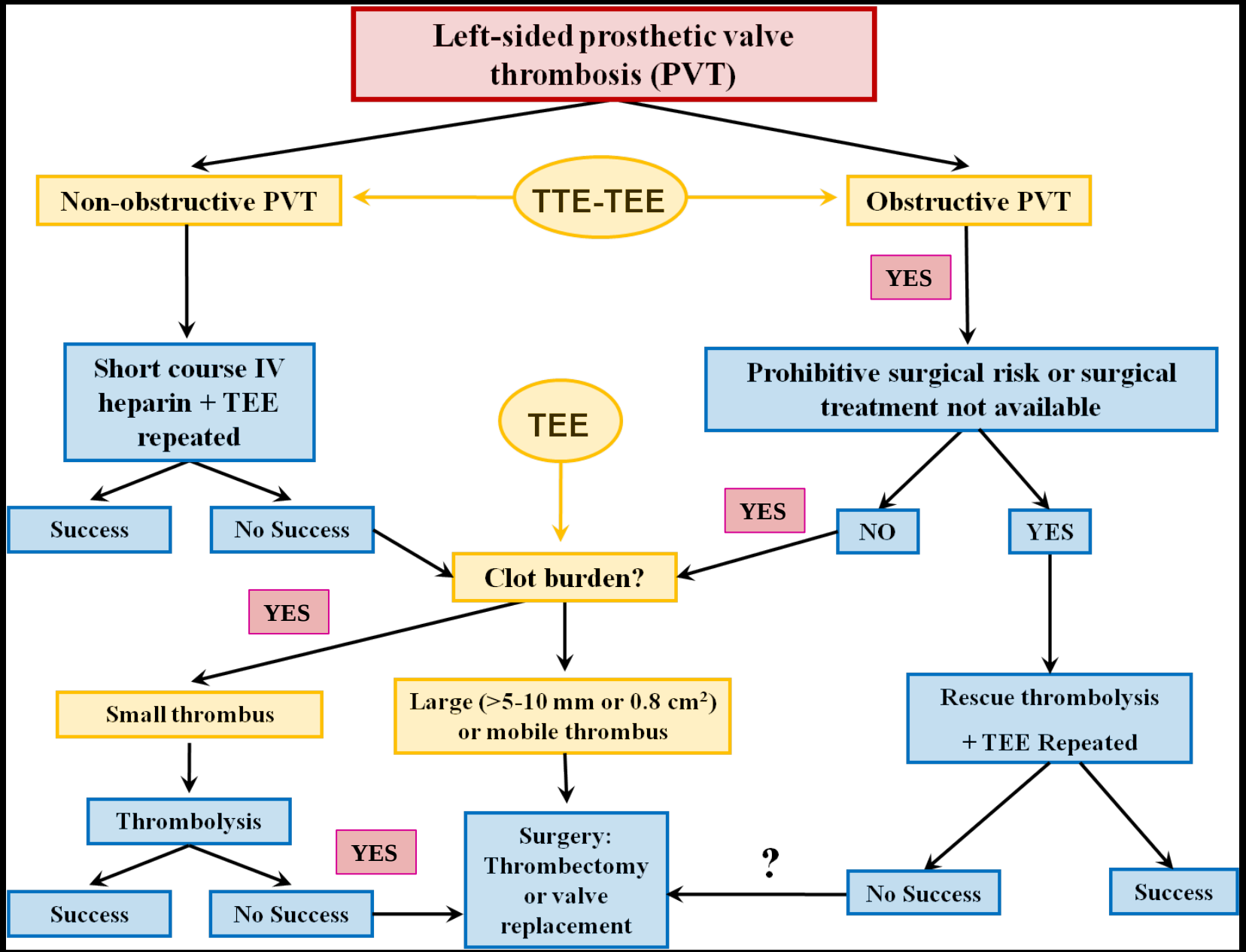




Zoghbi et al. J Am Soc Echocardiogr, 22:975-1014, 2009.

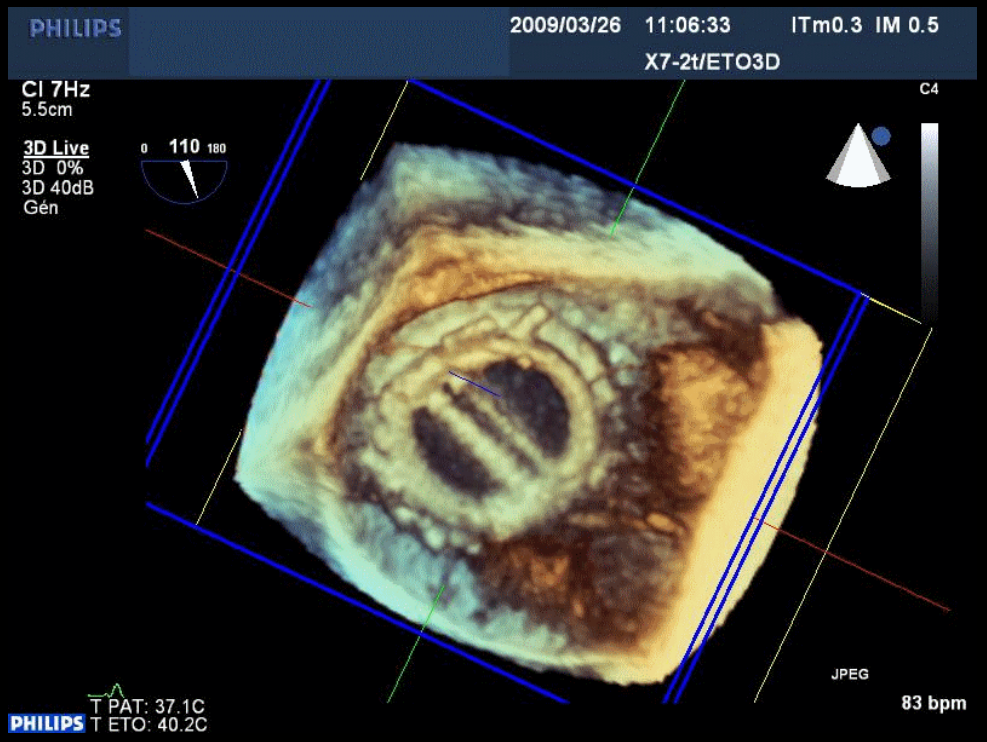


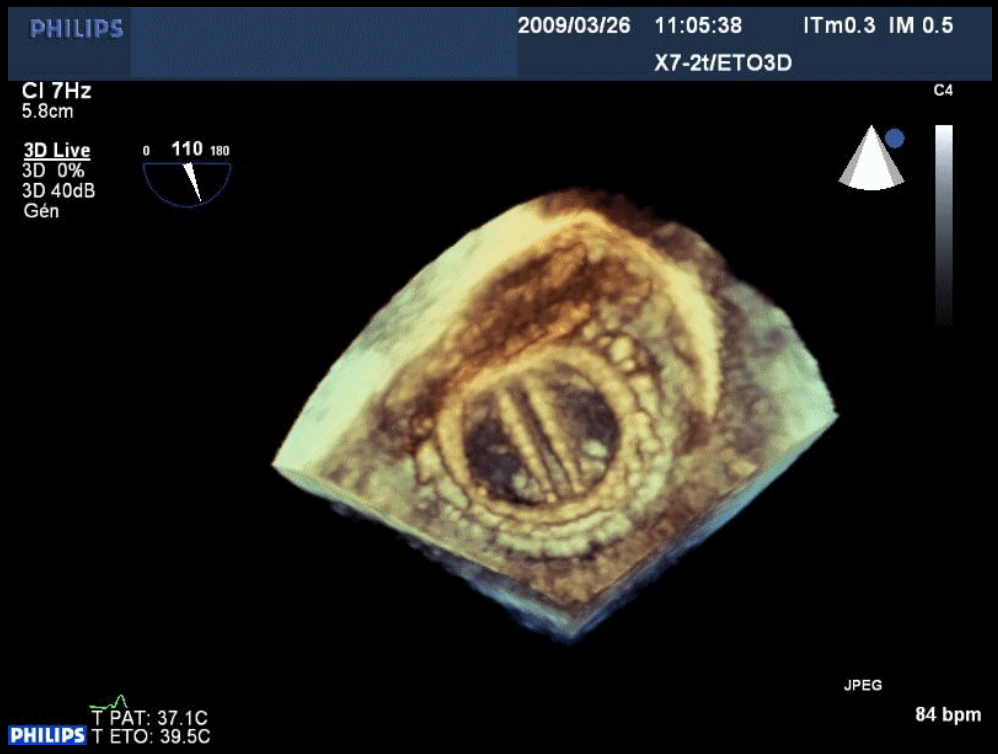
Pibarot & Dumesnil
Heart ; 98:69-78, 2012



Pibarot & Dumesnil, Circ 119:1034-48, 2009

3D Echo for Evaluation of Prosthetic Valve Function





Case #1

- 3 yr. post AVR
- Carbomedics 19
- NYHA III
- Echo
  - Gradients: 69/40
  - EOA: 1.1 cm^2
- Severe PPM

Case #2

- 1 yr. Post MVR
- OnX 25
- Asymptomatic
- Echo
  - Gradients: 11/6
  - EOA: 1.1 cm^2
- Severe dysfunction: Thrombus

Key Points

- **High gradient does not always mean prosthesis dysfunction**
- **Low gradient does not always mean normal prosthesis function**
- **Multi-parametric approach is key to appropriately differentiate normal function vs. PPM vs. dysfunction**

Key Points

PPM

- High Gradient
- Small indexed EOA
- EOA ~ normal
- Intermediate DVI
- Intermediate AT/LVET
- Normal leaflet morphology / mobility

Dysfunction

- High Gradient
- Small indexed EOA
- EOA << normal
- Small DVI
- Low AT/LVET
- Abnormal leaflet morphology / mobility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Entrée du
personnel
seulement

Useful References

GUIDELINES AND STANDARDS

Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound

A Report From the American Society of Echocardiography's Guidelines and Standards Committee and the Task Force on Prosthetic Valves, Developed in Conjunction With the American College of Cardiology Cardiovascular Imaging Committee, Cardiac Imaging Committee of the American Heart Association, the European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography and the Canadian Society of Echocardiography, Endorsed by the American College of Cardiology Foundation, American Heart Association, European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography, and Canadian Society of Echocardiography

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Education in Heart

VALVULAR HEART DISEASE

Doppler echocardiographic evaluation of prosthetic valve function

Philippe Pibarot,[1] Jean G Dumesnil[2]

Pibarot & Dumesnil Heart 2012; 98:69-78, 2012

EXPERT CONSENSUS STATEMENT

EAE/ASE Recommendations for the Use of Echocardiography in New Transcatheter Interventions for Valvular Heart Disease

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Zamorano JL; J Am Soc Echocardiogr 2011;24:937-65