That this House believes multimodality imaging assessment and treatment are needed in suspected subclinical prosthetic valve thrombosis.

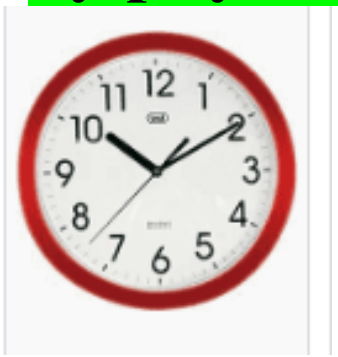
Mauro Pepi, MD, FESC
Clinical Director
Centro Cardiologico Monzino, IRCCS
Milan
ITALY

“suspected subclinical prosthetic valve thrombosis” ????

Includes several different conditions

DEFINITION Subclinical:

without signs and symptoms that are detectable by physical examination or laboratory test; not clinically manifest.



10 MINUTES

- **Mechanical Valves:**
- Low gradients with thrombosis
- Intermittent Obstruction
- **Biological valve and TAVR** :
- Subclinical thrombosis

Journal of *Cardiovascular Development and Disease*

2022

MDPI

Review

The Role of Multimodality Imaging in Left-Sided Prosthetic Valve Dysfunction

Manuela Muratori [1], Laura Fusini [1,2,*], Maria Elisabetta Mancini [1], Gloria Tamborini [1], Sarah Ghulam Ali [1], Paola Gripari [1], Marco Doldi [1], Antonio Frappampina [1], Giovanni Teruzzi [1], Gianluca Pontone [1], Piero Montorsi [1,3] and Mauro Pepi [1]

TTE-Doppler evaluation must be performed using both flow-dependent parameters (V_{max}, DP_{peak}, DP_{mean}, EOA) as well as flow-independent parameters (DVI, AT, ET, and AT/ET).

The combined use of flow dependent and flow independent parameters allows a better discrimination between normal PV, prosthesis-patient-mismatch phenomenon, and PV obstruction

ECHO – Doppler (2D, 3D, new tools) is the first line technique but …..

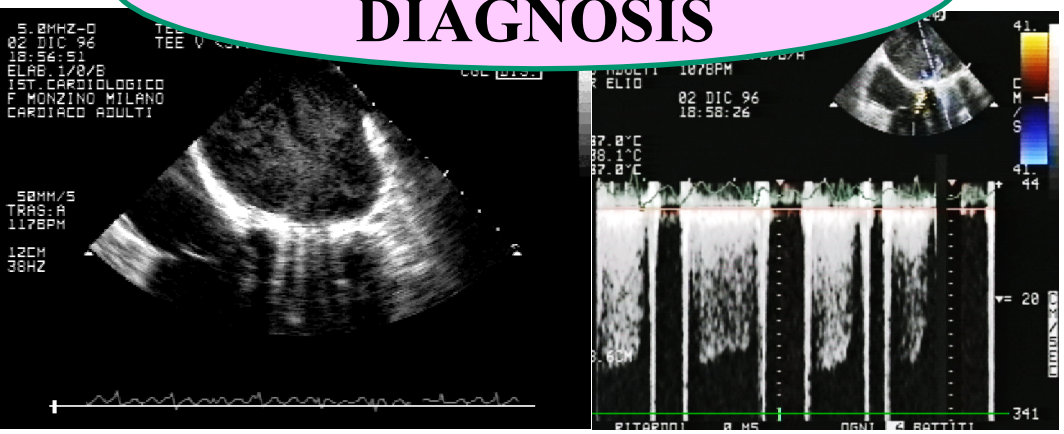
Abnormal Mean gradient in our lab on the basis of several studies

- **Mitral prosthesis:**
- **Any mean pressure gradient value 8 mmHg** was, therefore, considered as abnormal
- **Aortic Prosthesis**
- Depends on type and size of the prosthesis

Table 7 Normal reference values of effective orifice areas for the prosthetic aortic valves

Prosthetic valve size (mm)	19	21	23	25	27	29
Stented bioprosthetic valves						
Mosaic	1.1 ± 0.2	1.2 ± 0.3	1.4 ± 0.3	1.7 ± 0.4	1.8 ± 0.4	2.0 ± 0.4
Hancock II	–	1.2 ± 0.2	1.3 ± 0.2	1.5 ± 0.2	1.6 ± 0.2	1.6 ± 0.2
Carpentier-Edwards Perimount	1.1 ± 0.3	1.3 ± 0.4	1.5 ± 0.4	1.8 ± 0.4	2.1 ± 0.4	2.2 ± 0.4
Carpentier-Edwards Magna	1.3 ± 0.3	1.5 ± 0.3	1.8 ± 0.4	2.1 ± 0.5	–	–
Biocor (Epic)	1.0 ± 0.3	1.3 ± 0.5	1.4 ± 0.5	1.9 ± 0.7	–	–
Mitroflow	1.1 ± 0.2	1.2 ± 0.3	1.4 ± 0.3	1.6 ± 0.3	1.8 ± 0.3	–
Trifecta	1.4	1.6	1.8	2.0	2.2	2.4
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	–
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
Prima Edwards	–	1.3 ± 0.3	1.6 ± 0.3	1.9 ± 0.4	–	–
Mechanical valves						
Medtronic-Hall	1.2 ± 0.2	1.3 ± 0.2	–	–	–	–
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
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
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
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
ATS Medical[a]	1.1 ± 0.3	1.6 ± 0.4	1.8 ± 0.5	1.9 ± 0.3	2.3 ± 0.8	–

VERY EASY DIAGNOSIS



CARDIOGENIC SHOCK in a Patient with a MITRAL PROSTHESIS

Mean Gradient: 27 mmHg

VERY Complex DIAGNOSIS

BUT ……

Am J Cardiol 2002

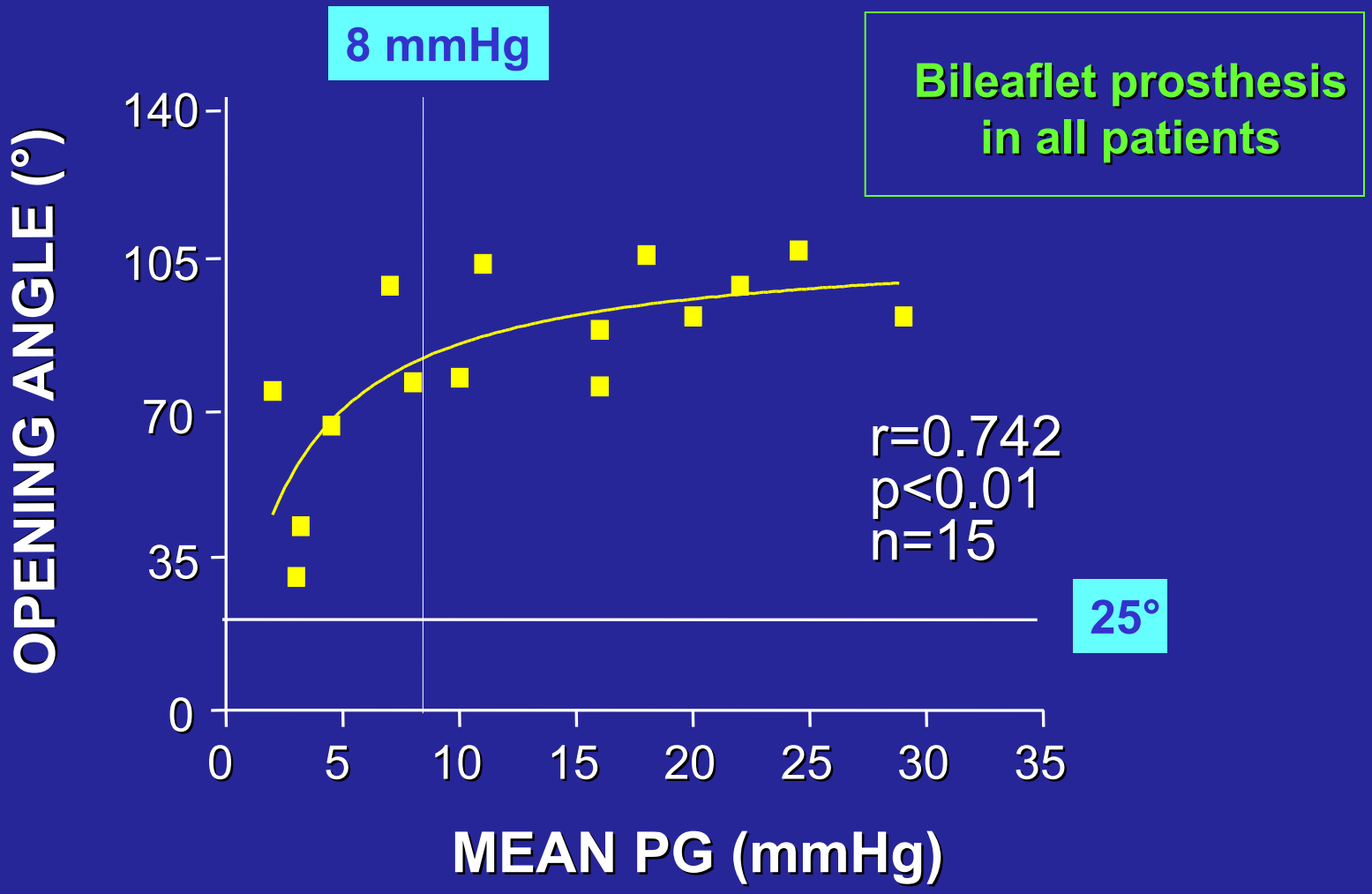
Diagnosing Prosthetic Mitral Valve Thrombosis and the Effect of the Type of Prosthesis

Piero Montorsi, MD, Dario Cavoretto, MD, Alessandro Parolari, MD, PhD, Manuela Muratori, MD, Marina Alimento, MD, and Mauro Pepi, MD

Up to 24% of patients with proved Prosthetic Mitral Valve Thrombosis have normal Doppler mean pressure gradient at rest

PROSTHETIC MITRAL VALVE THROMBOSIS

EFFECT OF PROSTHESIS TYPE ON DOPPLER PRESSURE GRADIENT

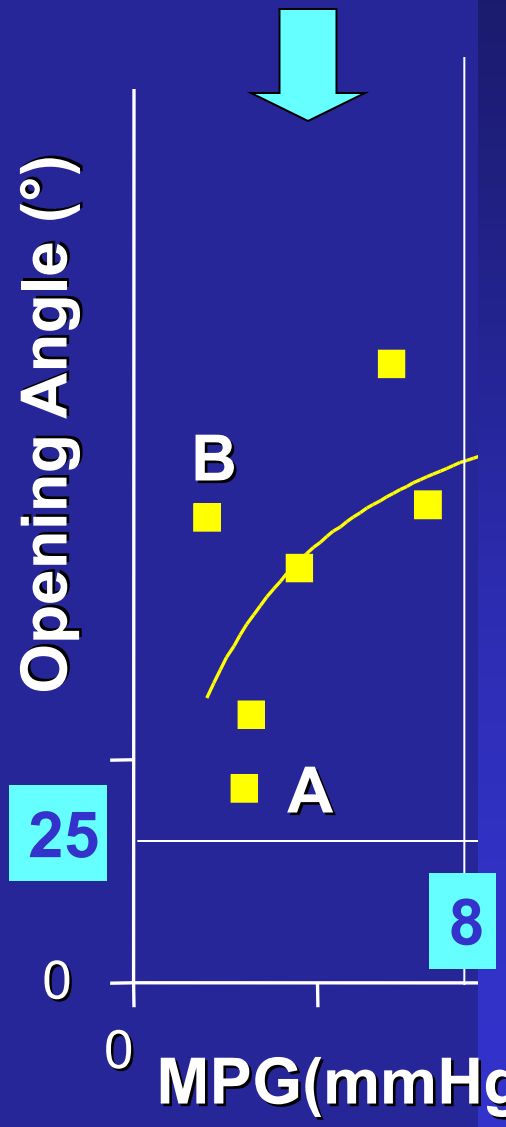


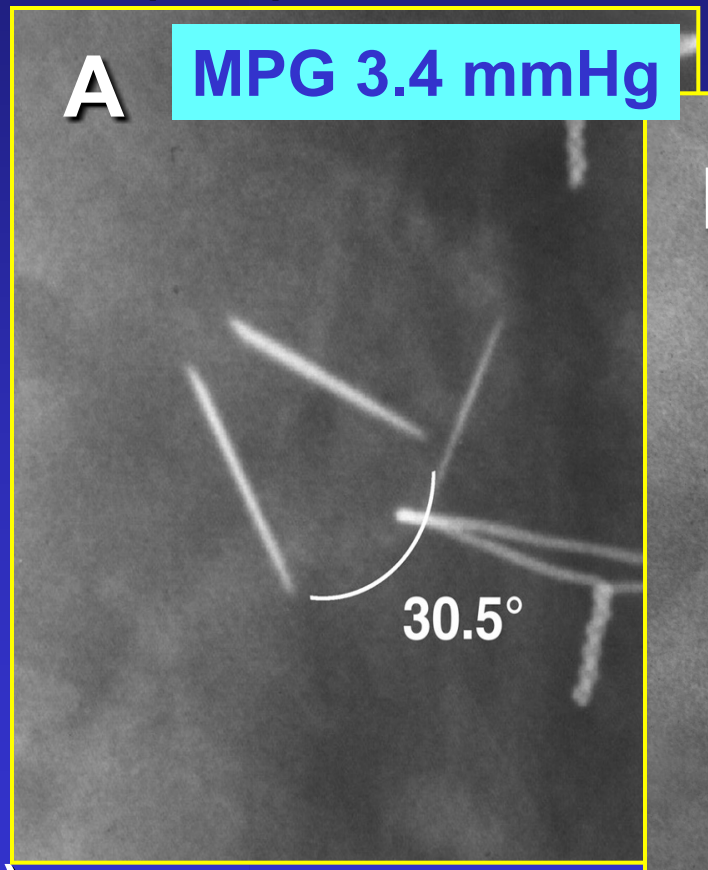
Montorsi Am J Cardiol 2002

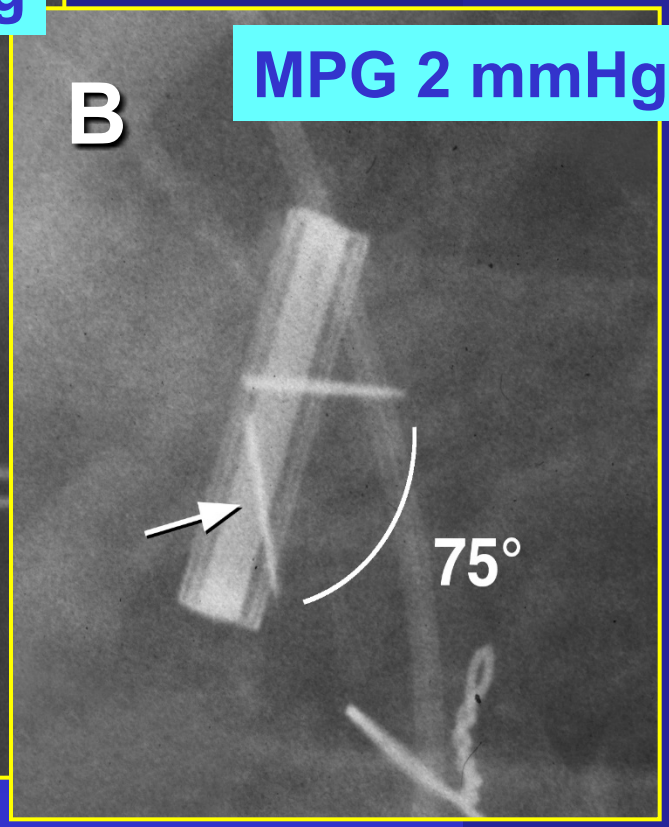
HONEY MOON PHASE

6/15(40%) pts. Mean PG: 4.6±2.3 mmHg

Clinical presentation: no symptoms (n=3); transient cerebral ischaemia (n=3)



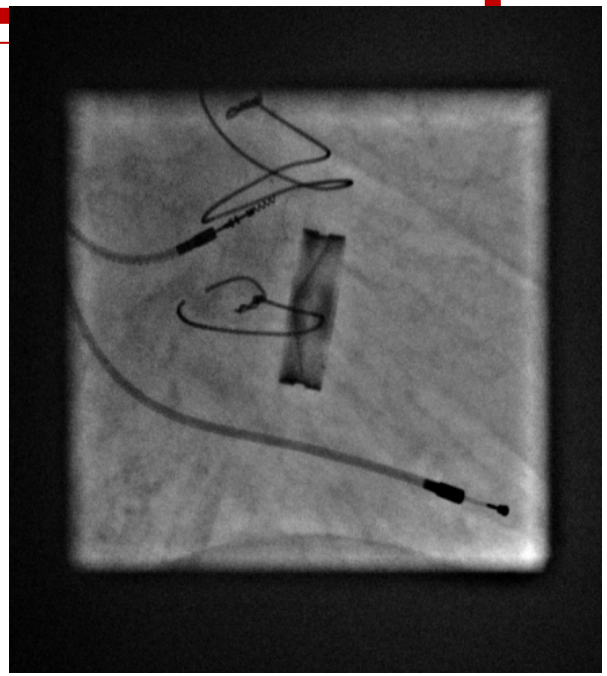




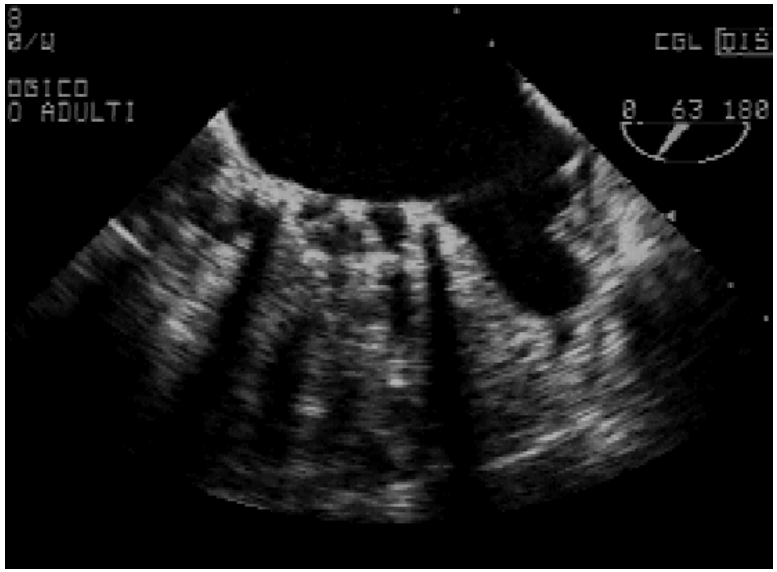
Montorsi Eur Heart 2001

Prosthetic valve dysfunction

COMPLEMENTARY ROLE OF CINEFLUOROSCOPY and Disc Motion Evaluation (by ECHO)



- Doppler Silent Obstruction
- Intermittent Obstruction
- High prosthetic aortic gradients
- Intraprosthetic physiological vs pathological regurgitant jets
- Rapid decision making in Thrombolysis vs Surgery



Clinical Case

60 Years Lady

1990 Surgical Mitral Commissurotomy

2002 Percutaneous Commissurotomy

2006 Bileaflet Mitral Prosthesis and Pace Maker

2009 NYHA Class I / Parossistic atrial fibrillation
Scheduled for Atrial Ablation

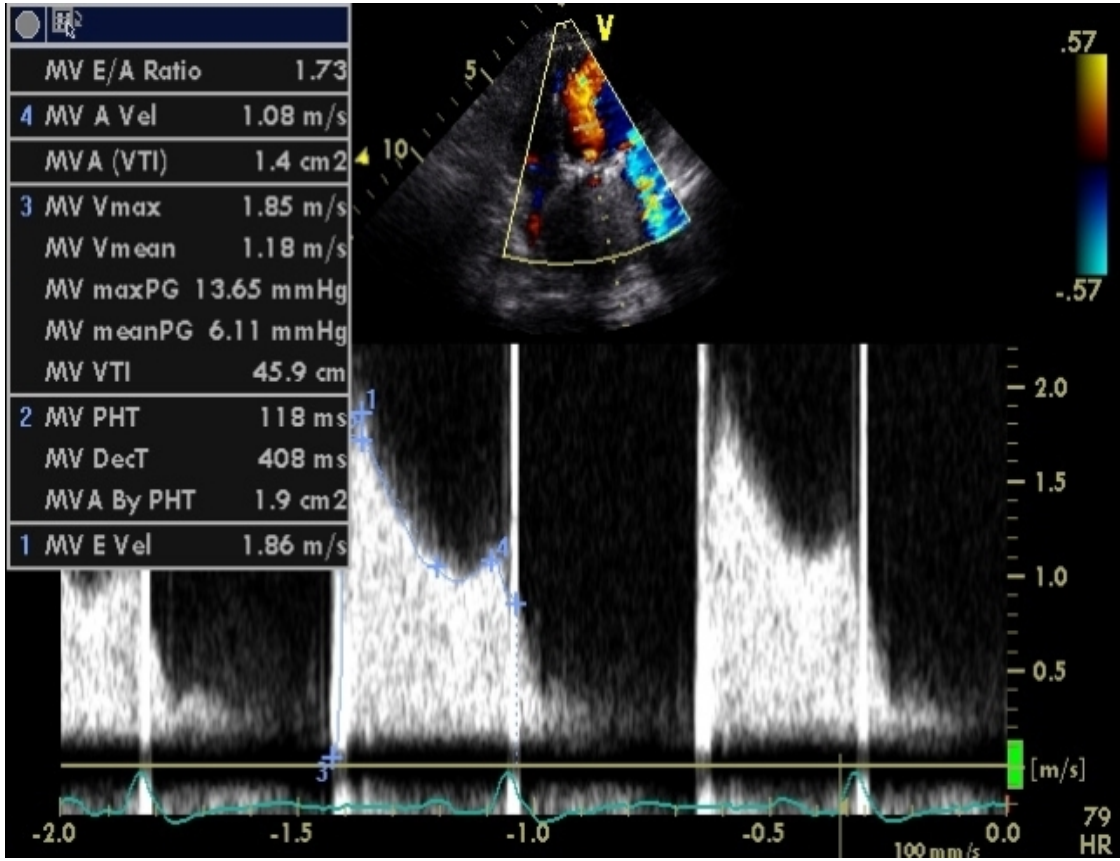
Transthoracic echo and TEE before the procedure

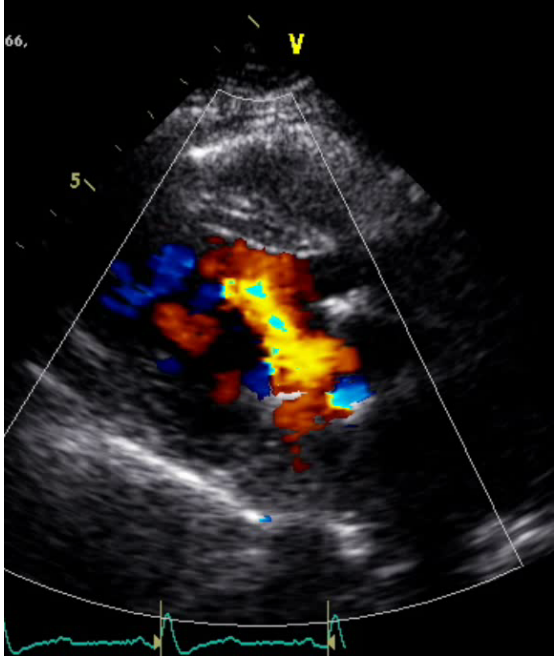
Transthoracic echo

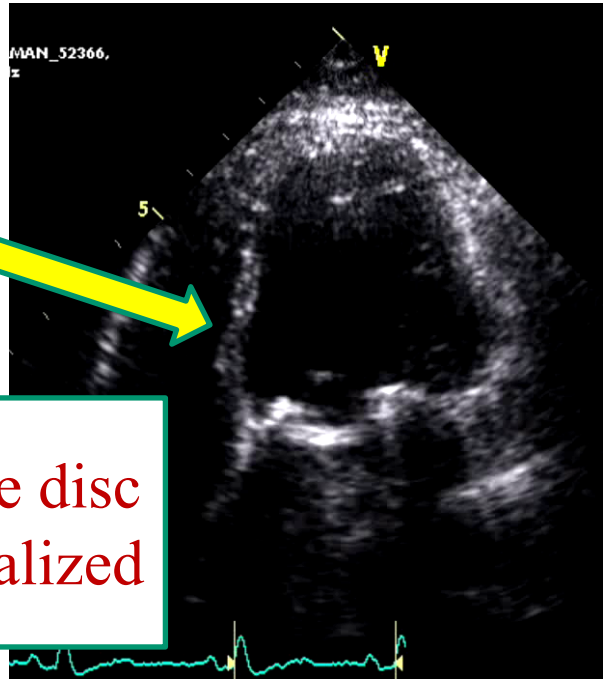
Suboptimal visualization of leaflets

Mean MP gradient 6 mmHg

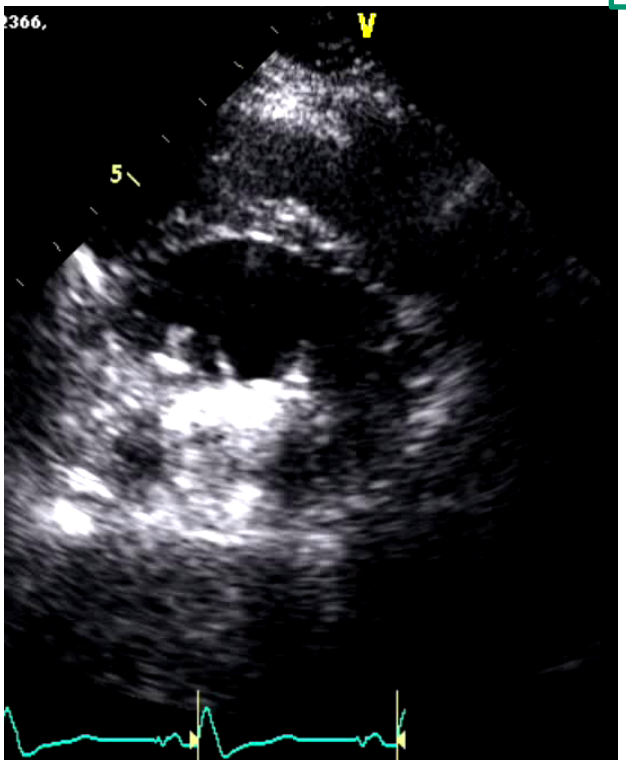
Abnormal flow direction (distorted Jet)

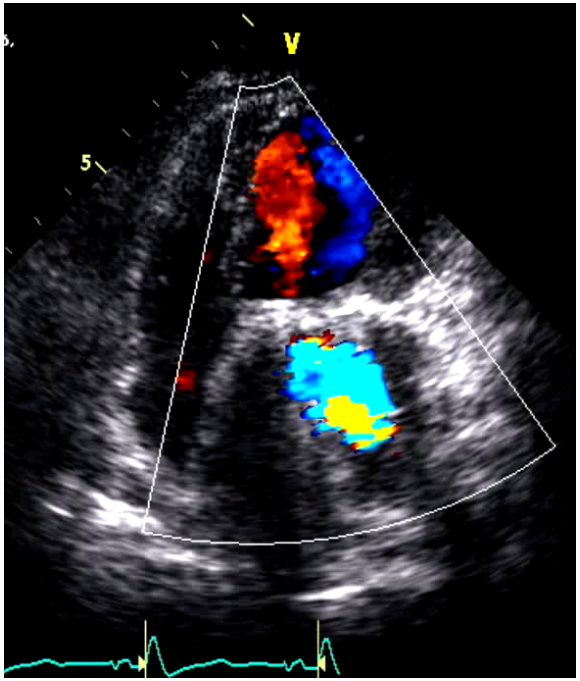






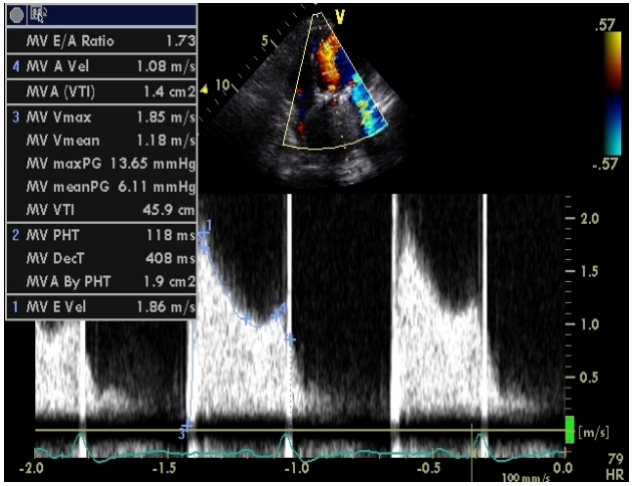
Only One disc was visualized

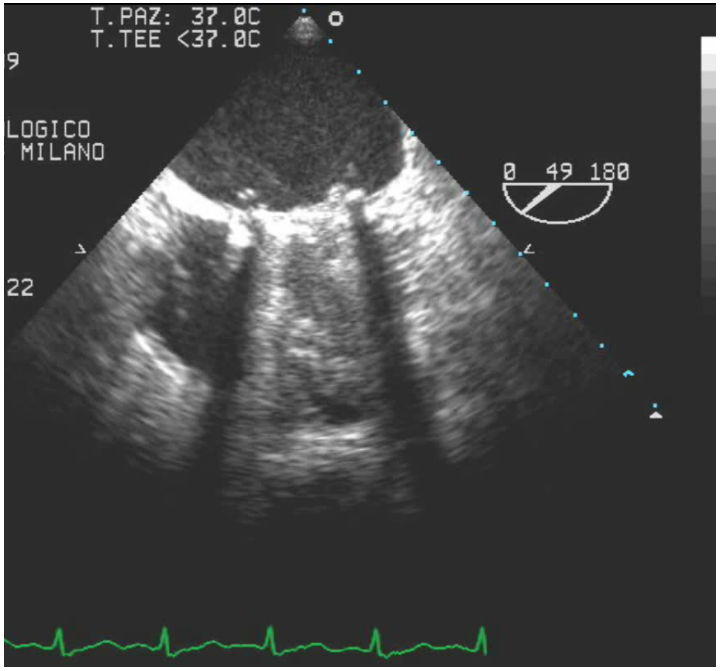


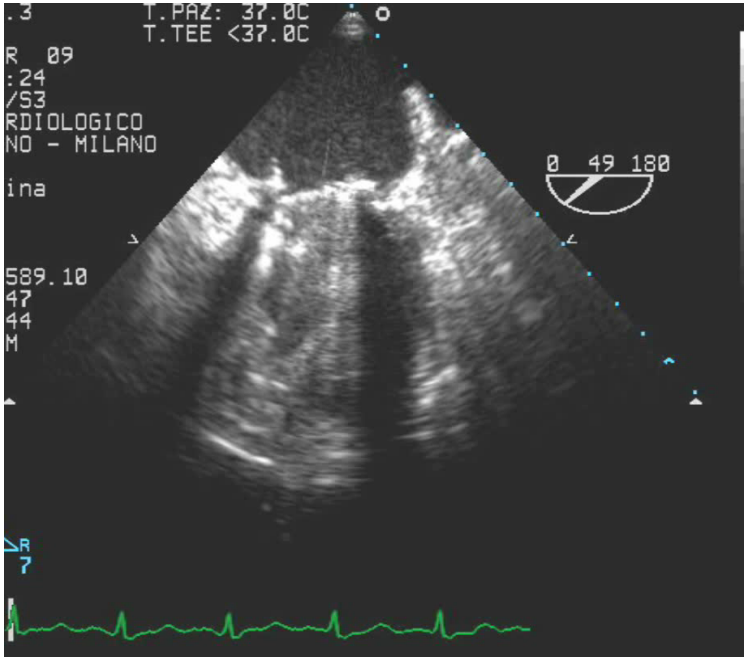


TOE

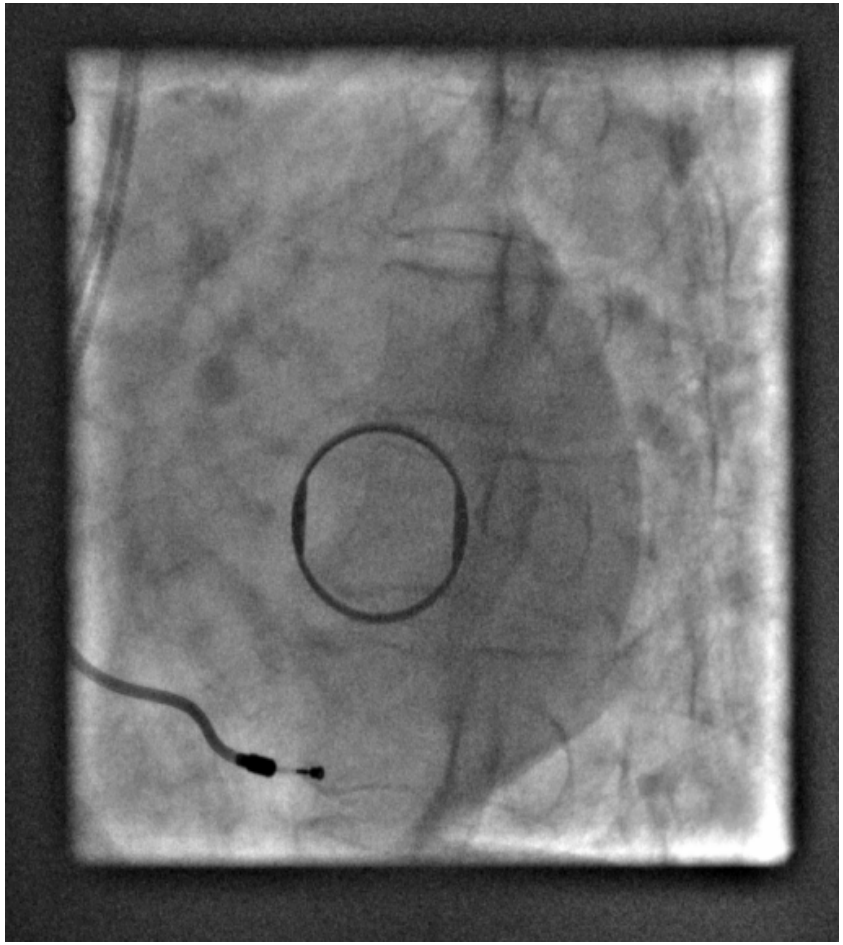
Mean Gradient 6 mmHG

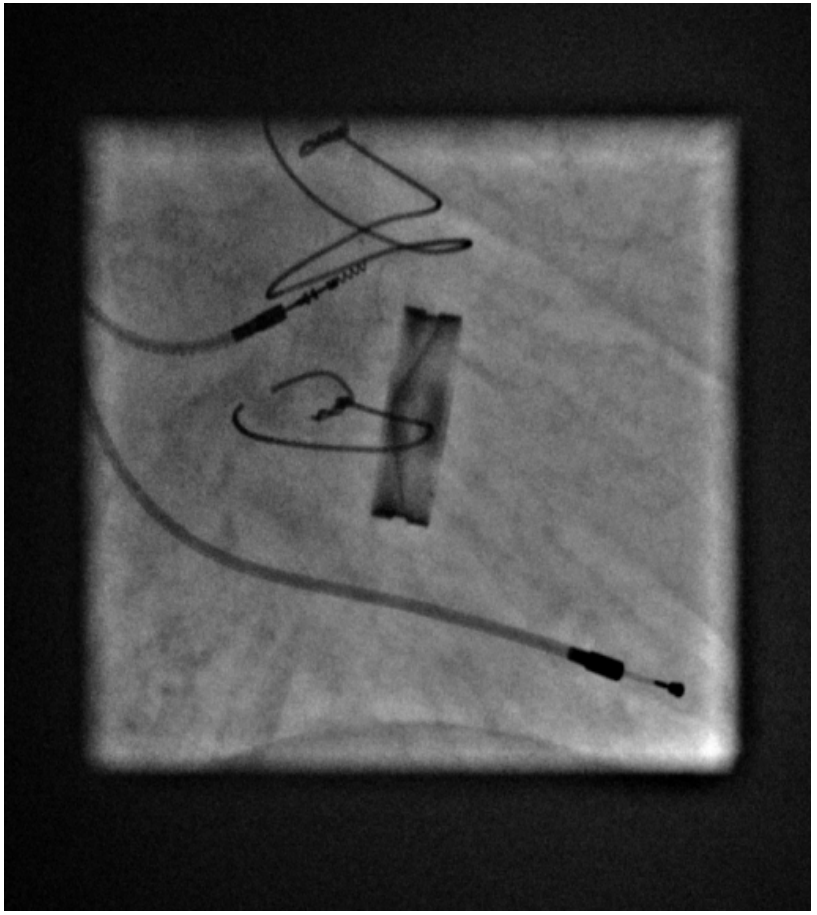






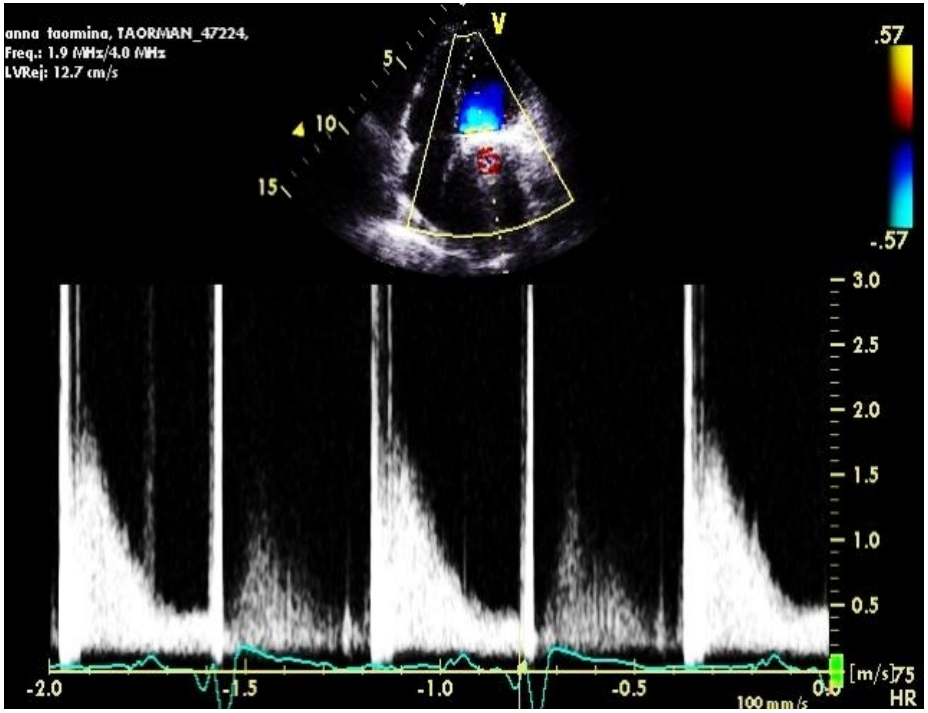
CINEFLUOROSCOPY





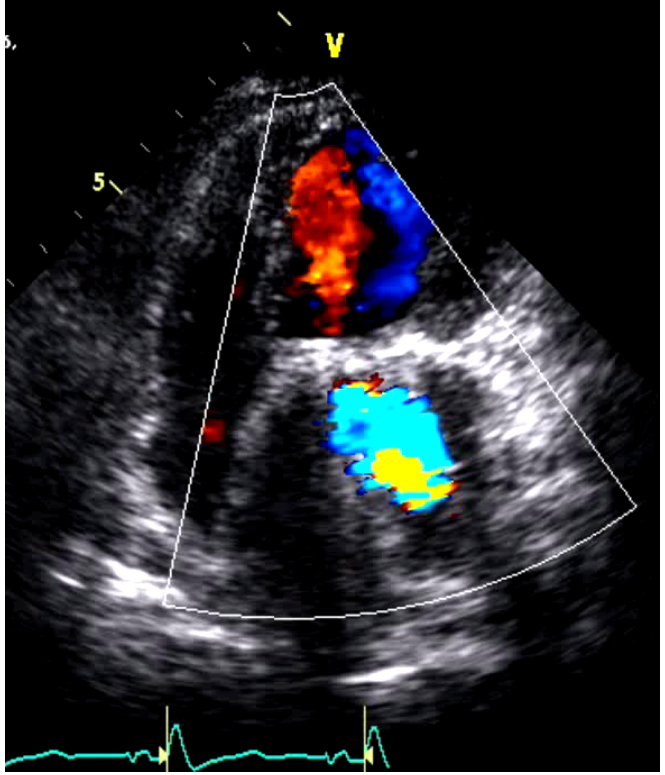
March 5th

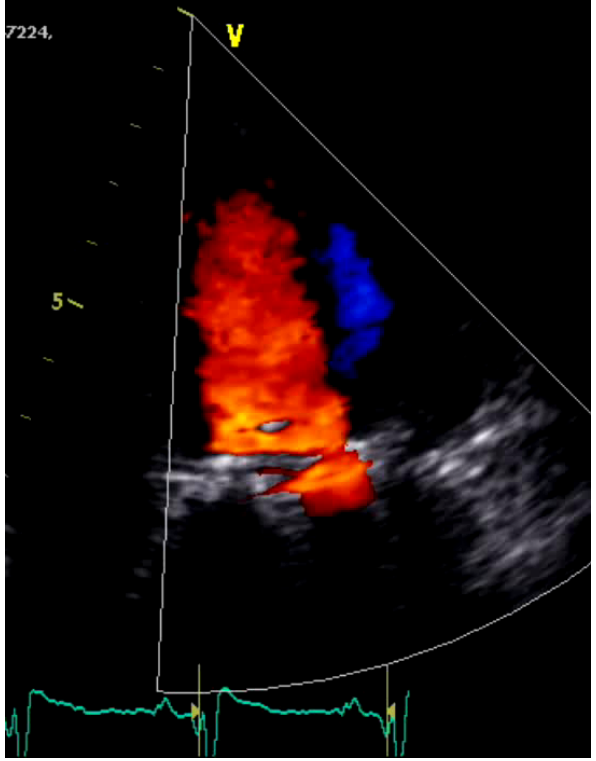
Thrombolysis



Pre-Thrombolysis
Mean Grad 6 mmHg

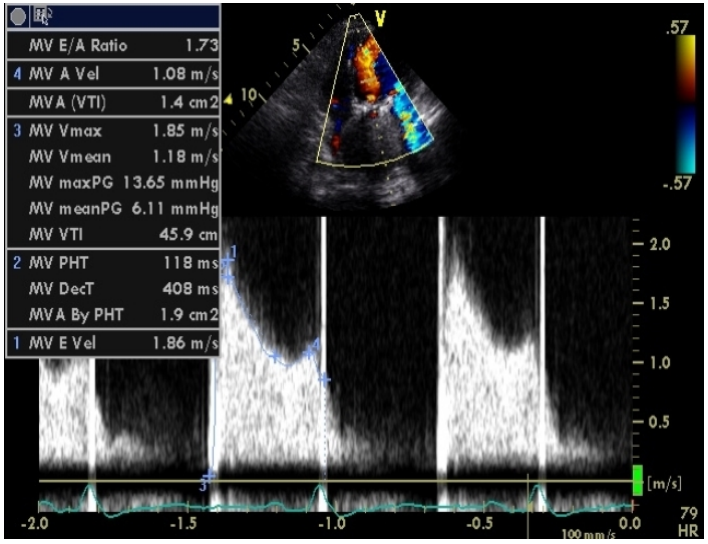
Post-Thrombolysis
Mean Gradient 2.5 mmHg

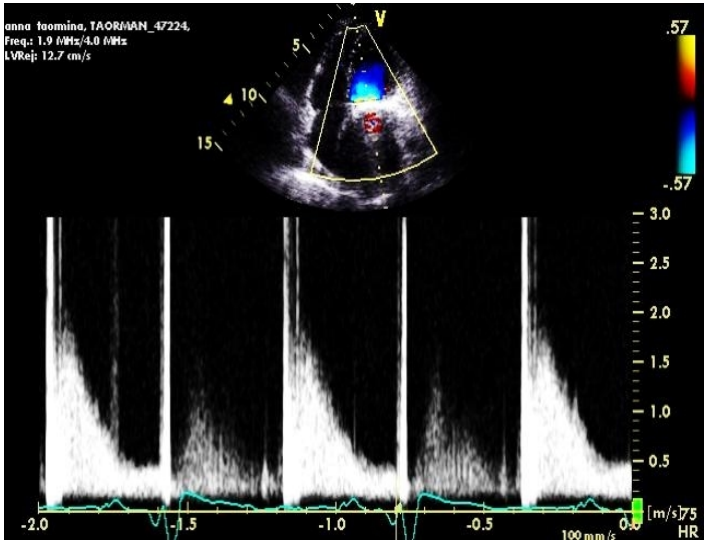




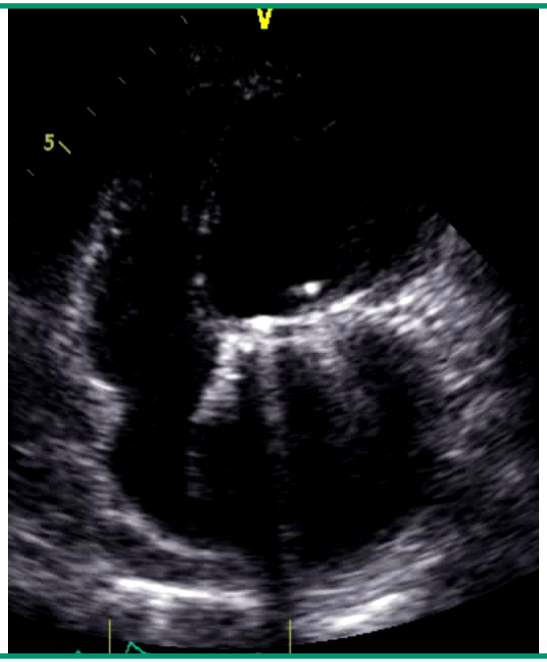
BASELINE

THROMBOLYSIS

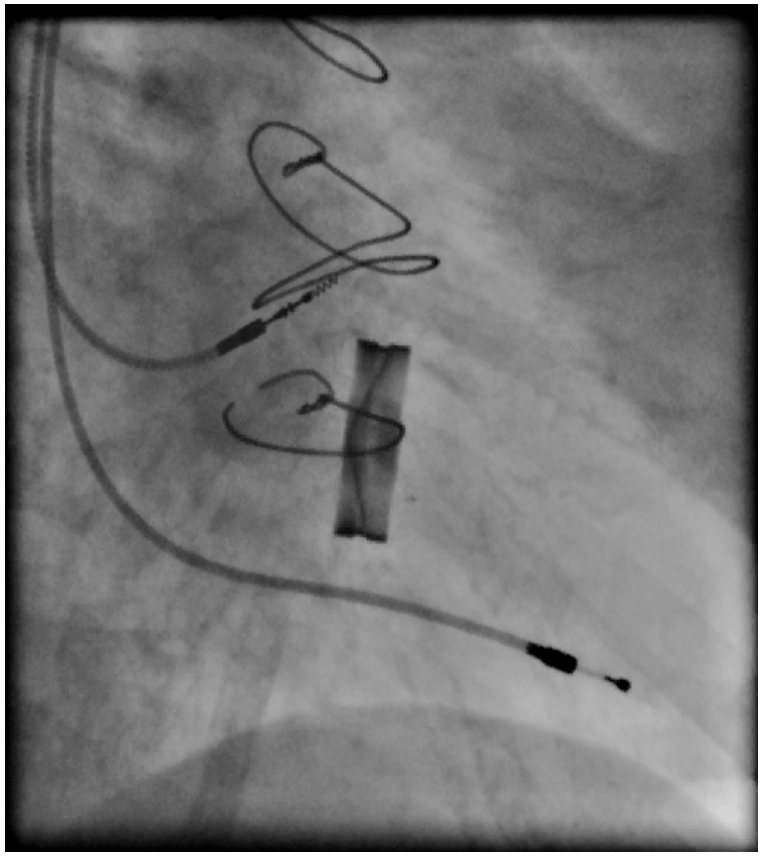




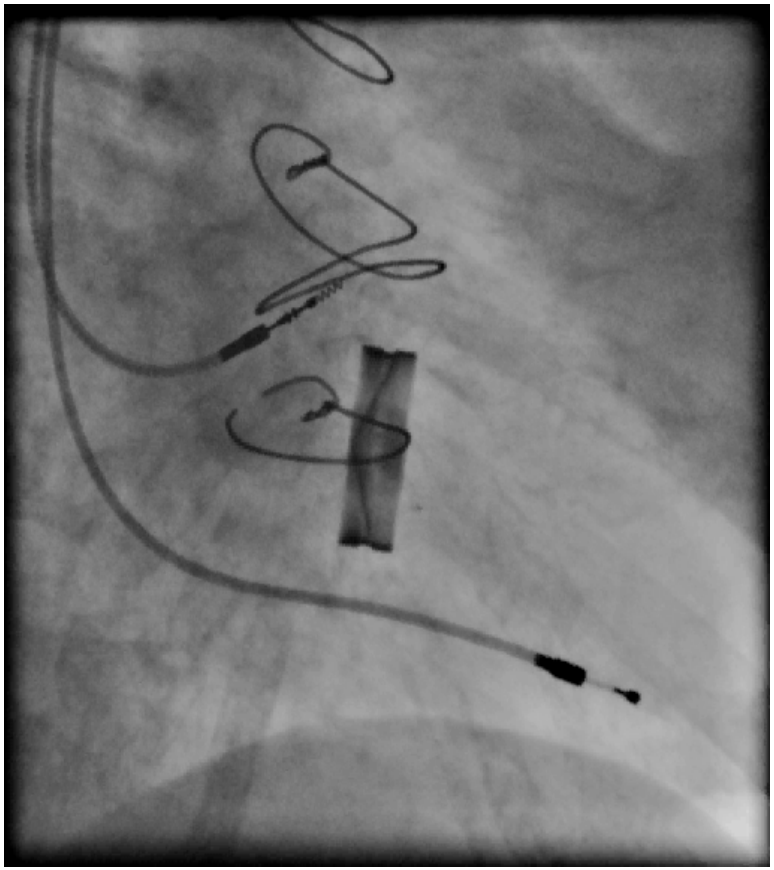
Despite normalization of mean gradient and apparently normal color flow ……



Suboptimal visualization of discs ?
Abnormal motion of one disc ?

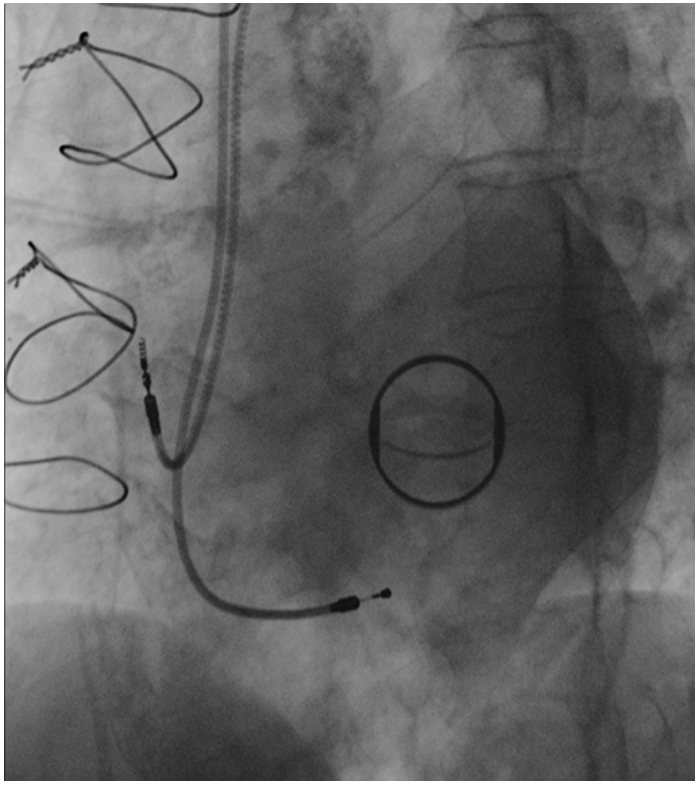


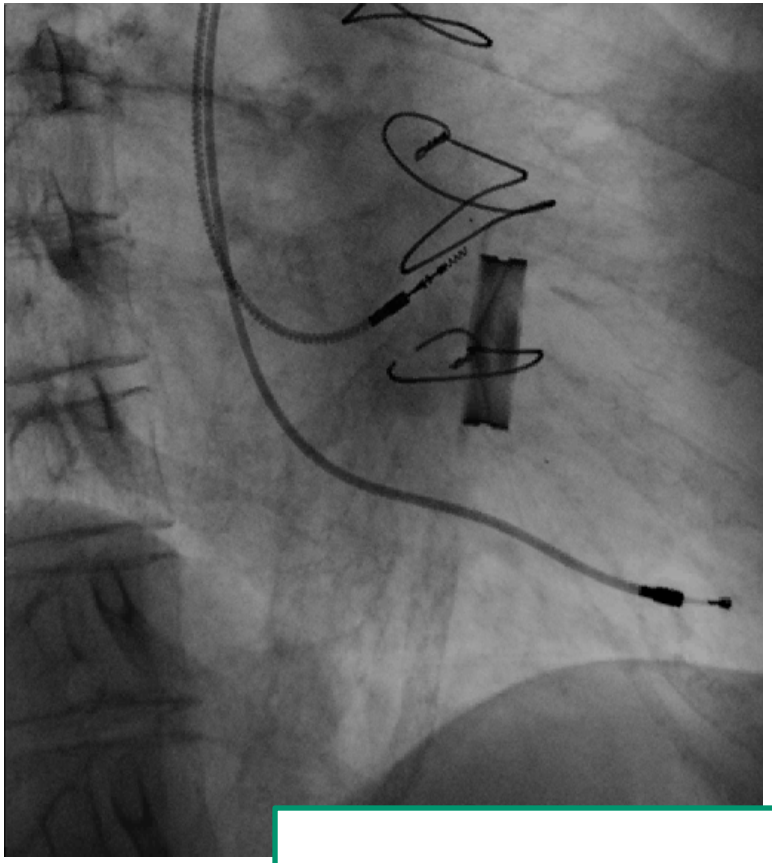
March 7th



March 8th

CINEFLUOROSCOPY

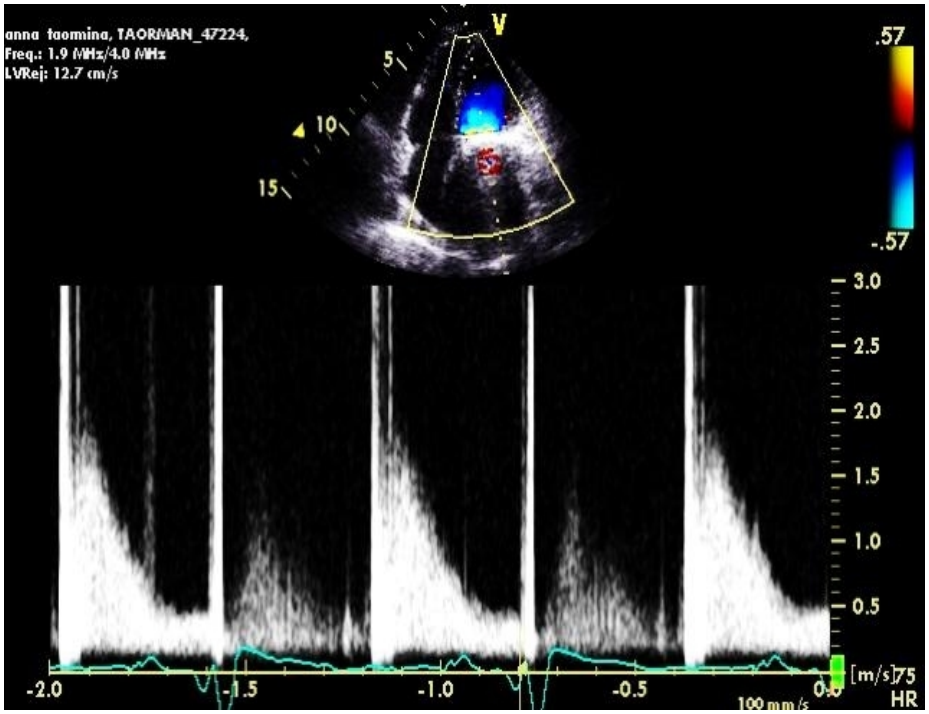


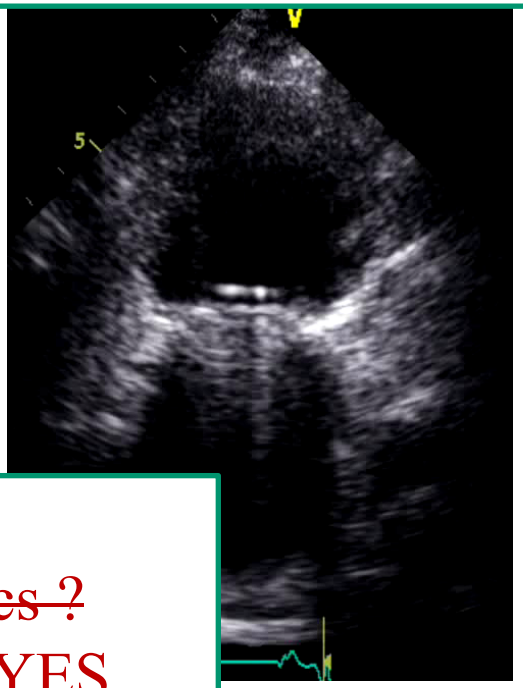


March 9th

True normalization of the 2 discs

True normalization of the 2 discs





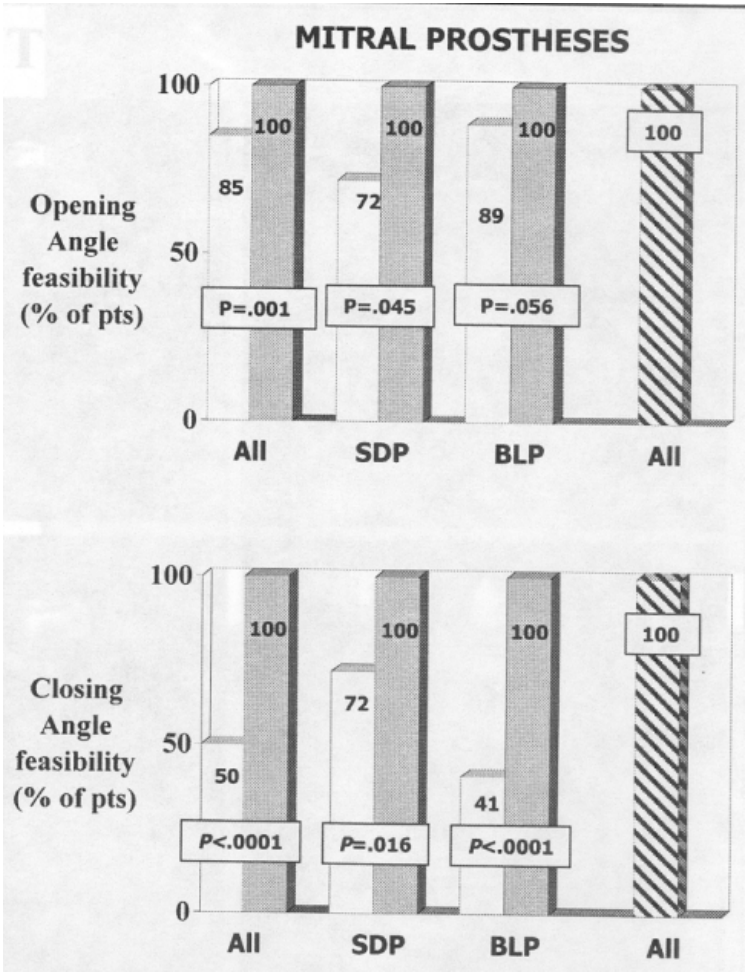
~~Suboptimal visualization of discs ?~~

Abnormal motion of one disc ? YES

Feasibility and Diagnostic Accuracy of Quantitative Assessment of Mechanical Prostheses Leaflet Motion by Transthoracic and Transesophageal Echocardiography in Suspected Prosthetic Valve Dysfunction

Manuela Muratori, MD*, Piero Montorsi, MD, Giovanni Teruzzi, MD, Fabrizio Celeste, MD, Elisabetta Doria, MD, Francesco Alamanni, MD, and Mauro Pepi, MD

(Am J Cardiol 2006;97:94–100)

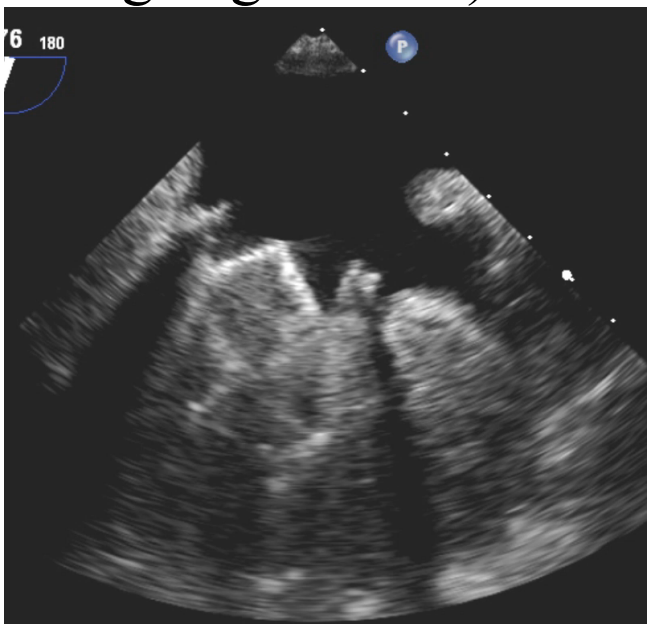


FEASIBILITY

Cinefluoroscopy: 100%

TTE: 77 % (Closing angles 50%)

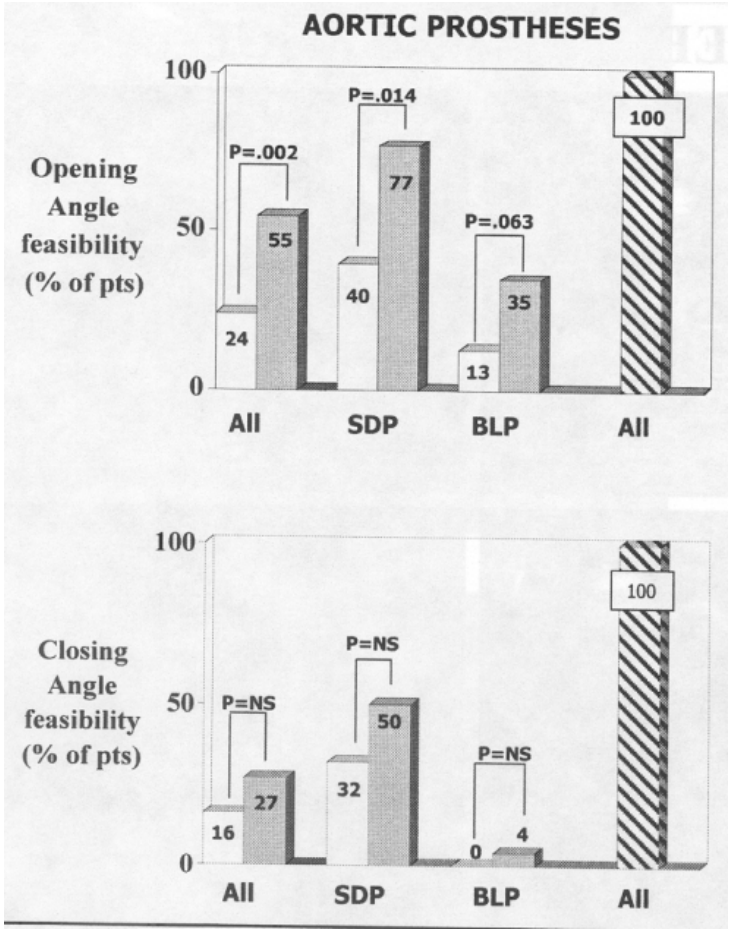
TEE: 100%



Feasibility and Diagnostic Accuracy of Quantitative Assessment of Mechanical Prostheses Leaflet Motion by Transthoracic and Transesophageal Echocardiography in Suspected Prosthetic Valve Dysfunction

Manuela Muratori, MD*, Piero Montorsi, MD, Giovanni Teruzzi, MD, Fabrizio Celeste, MD, Elisabetta Doria, MD, Francesco Alamanni, MD, and Mauro Pepi, MD

(Am J Cardiol 2006;97:94–100)

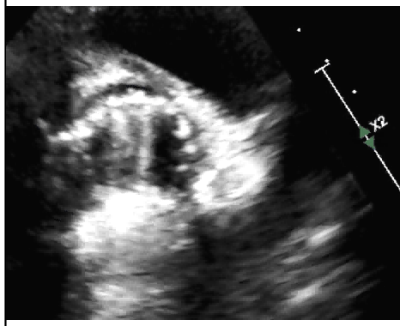


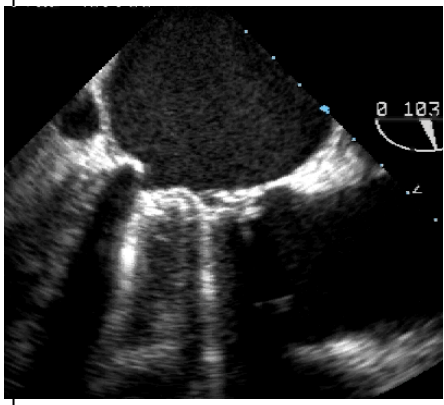
FEASIBILITY

Cinefluoroscopy: 100%

TTE: 13% Bileaflet; 40% Single DiskClosing Angles (0° e 32%)

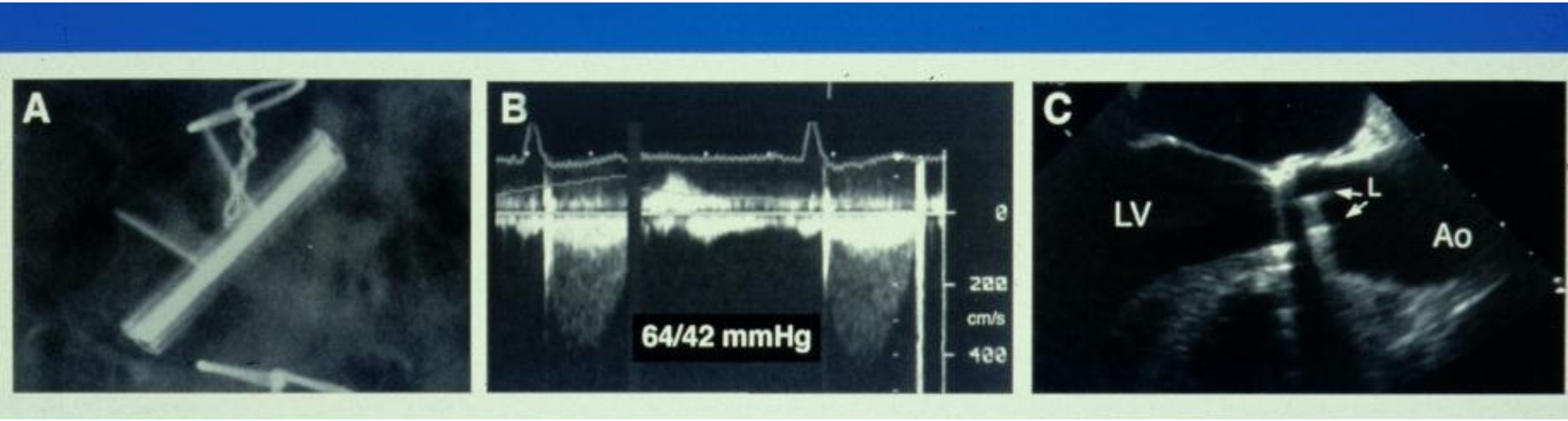
TEE: 35% Bileaflet; 77% Single Disk : Closing and Opening Angles (0 and 50 %)





Role of Cine-Fluoroscopy, Transthoracic, and Transesophageal Echocardiography in Patients With Suspected Prosthetic Heart Valve Thrombosis

Piero Montorsi, MD, Francesca De Bernardi, MD, Manuela Muratori, MD, Dario Cavoretto, MD, and Mauro Pepi, MD



Cinefluoroscopy and TTE are quick, effective and complementary diagnostic tools to diagnosis PV Thrombosis in most patients.
TEE still remain the gold standard technique in selected cases

Am J Cardiol 2000

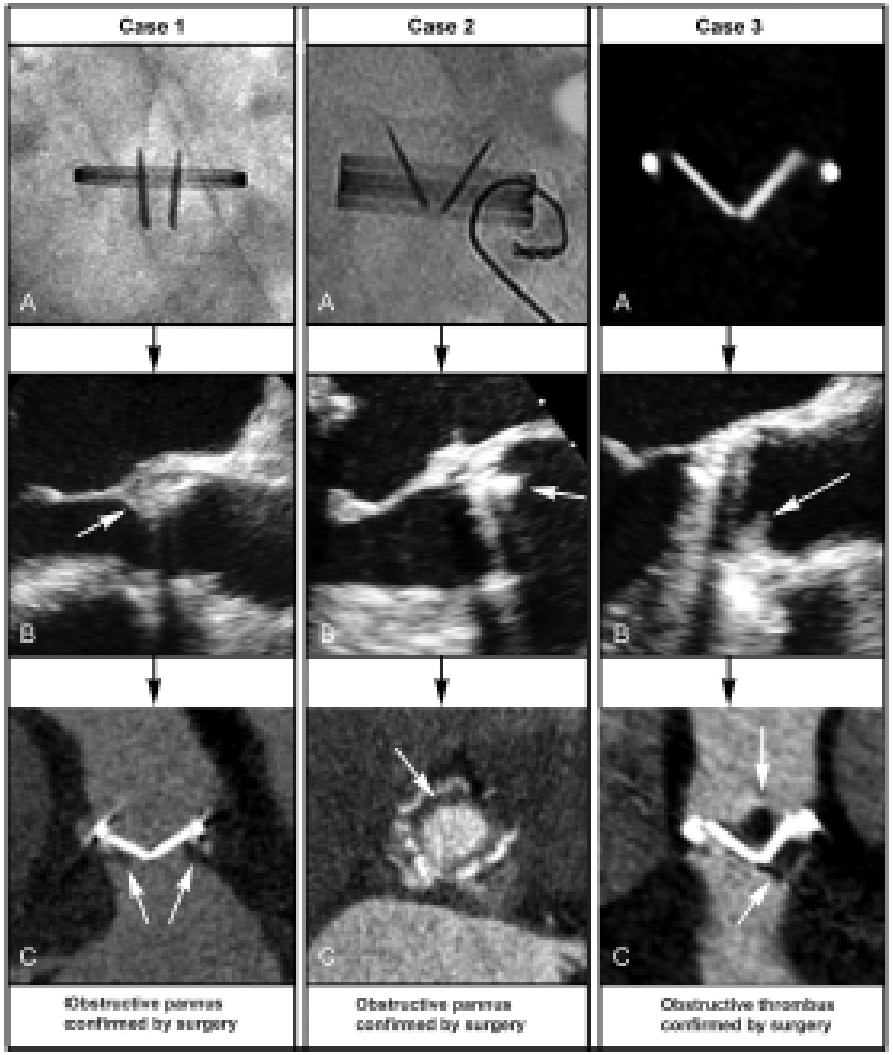
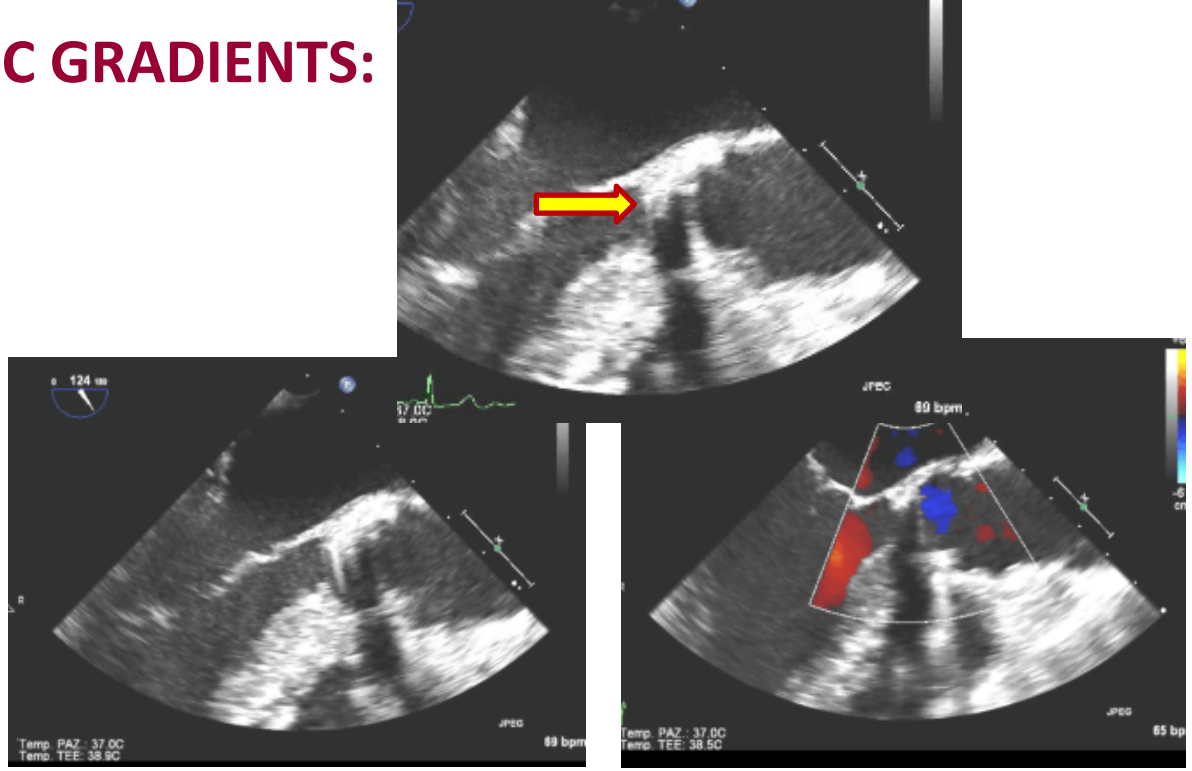


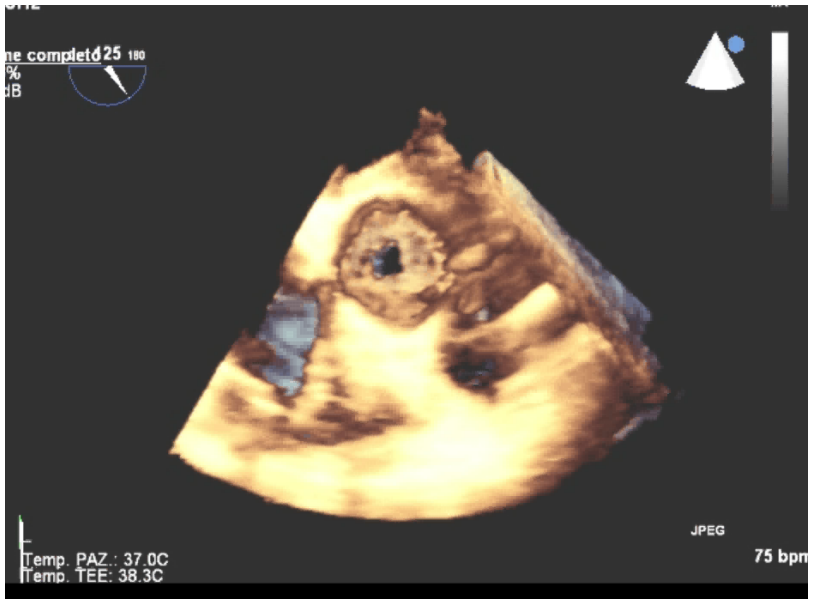
Figure 3 Patients with acquired mechanical PHV obstruction and suspicion on thrombosis. Case 1: (*A*) normal systolic opening angles of an aortic St Jude mechanical PHV detected by fluoroscopy. (*B*) 120° TEE, arrow pointing at subprosthetic tissue at the ventricular side. (*C*) MDCT in the diastolic phase with arrows pointing at the hypodense subvalvular tissue only located on the ventricular side curved along the PHV ring, which was pannus confirmed by surgery. Case 2: (*A*) both leaflets show systolic restriction at fluoroscopy. (*B*) aortic Tophat PHV imaged by TEE (120°) with arrow pointing at the PHV ring and its concomitant acoustic shadowing. (*C*) MDCT shows hypodense subprosthetic tissue only on the ventricular side curved along the PHV ring, which was pannus confirmed by surgery. Case 3: (*A*) both leaflets show systolic restriction detected by MDCT. (*B*) 120° TEE view with arrow pointing at an oscillating mass at the aortic side of the St Jude PHV. (*C*) MDCT shows an irregular shaped and hypodense mass directly attached to the occluder on the ventricular and aortic side, which was thrombus confirmed by surgery.

In case of mass detection by TEE, predictors for **obstructive thrombus masses** (compared with pannus masses) were **leaflet restriction, soft echo density, and increased mass length.**

In situations of inconclusive echocardiography, **MDCT** may correctly detect pannus/thrombus

HIGH TRANSPROSTHETIC GRADIENTS: PANNUS



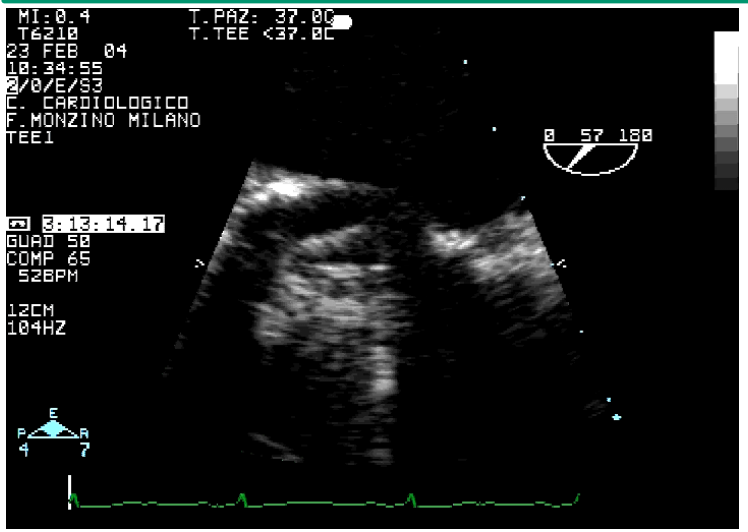


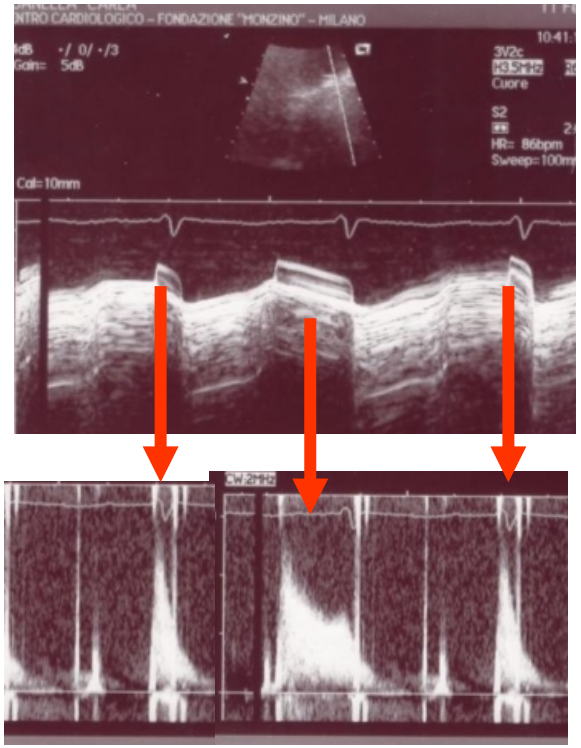
Diagnosis of Intermittent Obstruction of Mechanical Mitral Valve Prostheses by Doppler Echocardiography

Maie Shahid, MRCP, George Sutherland, MD, and Liv Hatle, MD

Flow variability; RT variability ; Am J Cardiology 1995

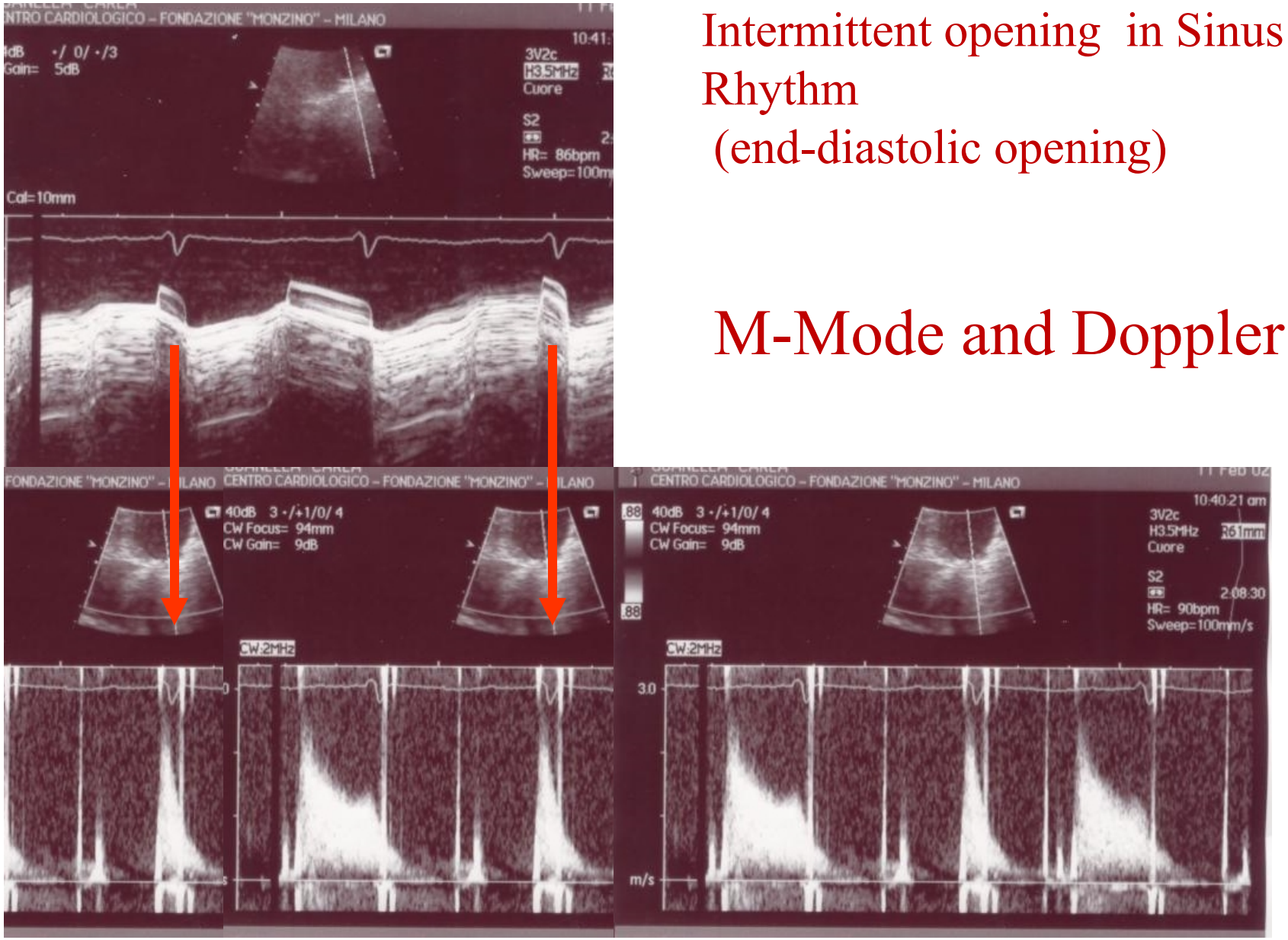
2 CASES of our SERIES





Intermittent opening in Sinus Rhythm
(end-diastolic opening)

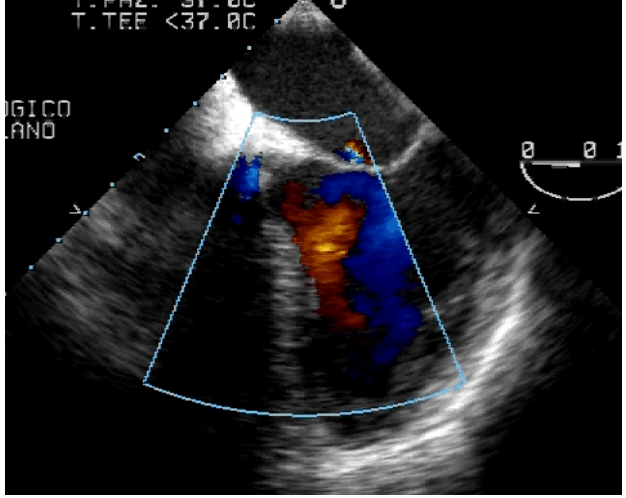
M-Mode and Doppler



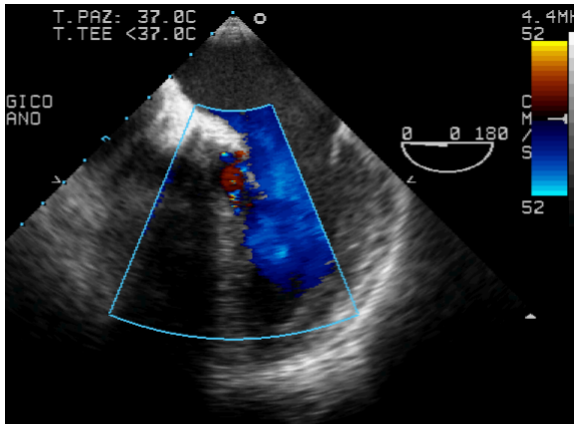
MITRAL PROSTHESIS : TRANSTHORACIC ECHO

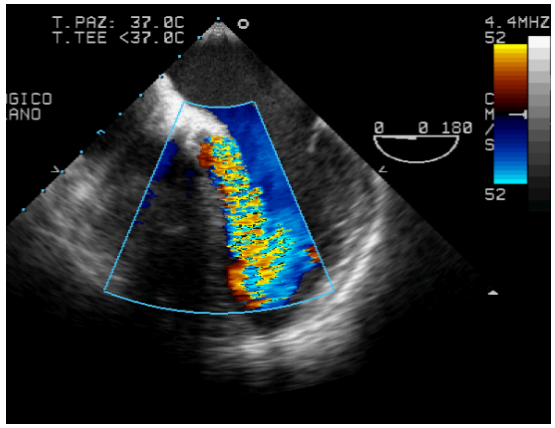
Asymptomatic; aortic severe Ao regurgitation every 6-7 beats

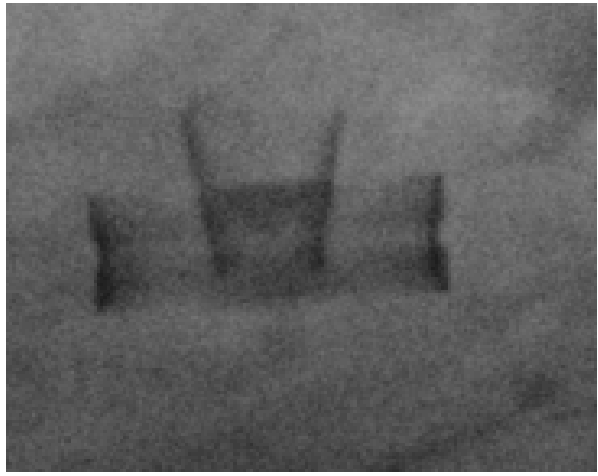
Galli et al JASE 2007



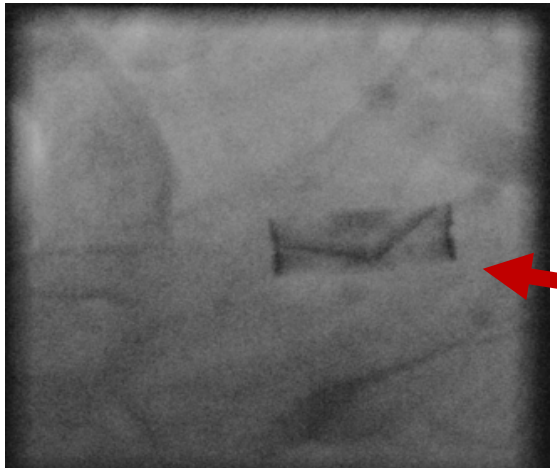
a







b



Even minimal closure defect may cause severe intermittent regurgitation

d

ORIGINAL RESEARCH

Dysfunction of Bileaflet Aortic Prosthesis

Accuracy of Echocardiography Versus Fluoroscopy

Manuela Muratori, MD,* Piero Montorsi, MD,*† Francesco Maffessanti, PHD,* Giovanni Teruzzi, MD,* William A. Zoghbi, MD,‡ Paola Gripari, MD,* Gloria Tamborini, MD,* Sarah Ghulam Ali, MD,* Laura Fusini, MS,* Cesare Fiorentini, MD,*† Mauro Pepi, MD*

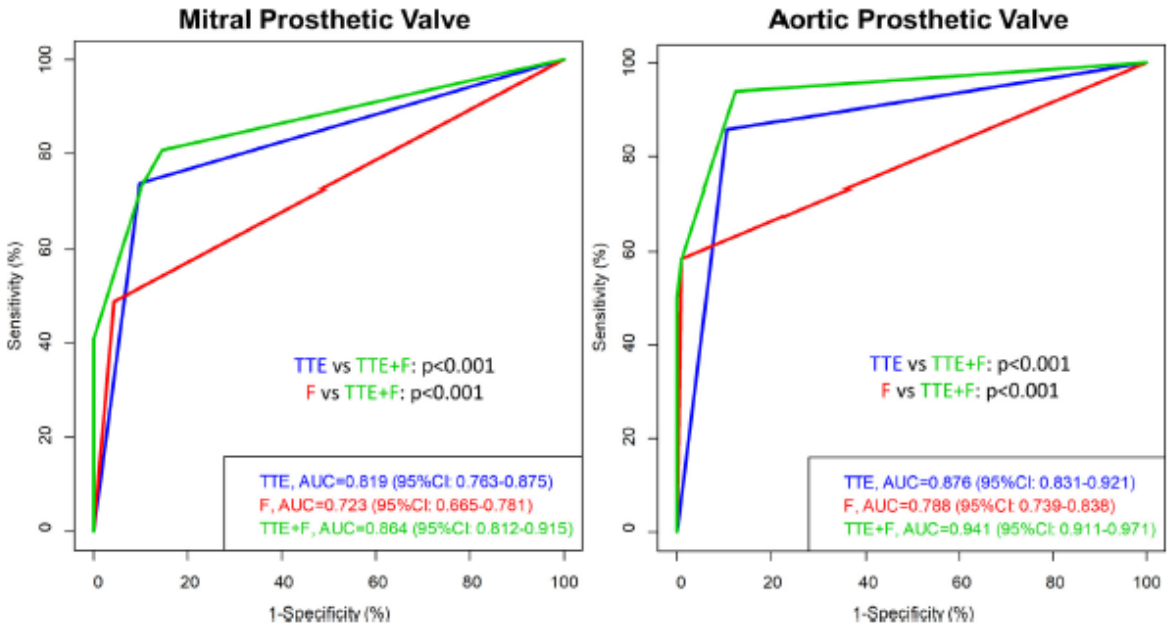
Milan, Italy; and Houston, Texas

J Am Coll Cardiol Img 2013

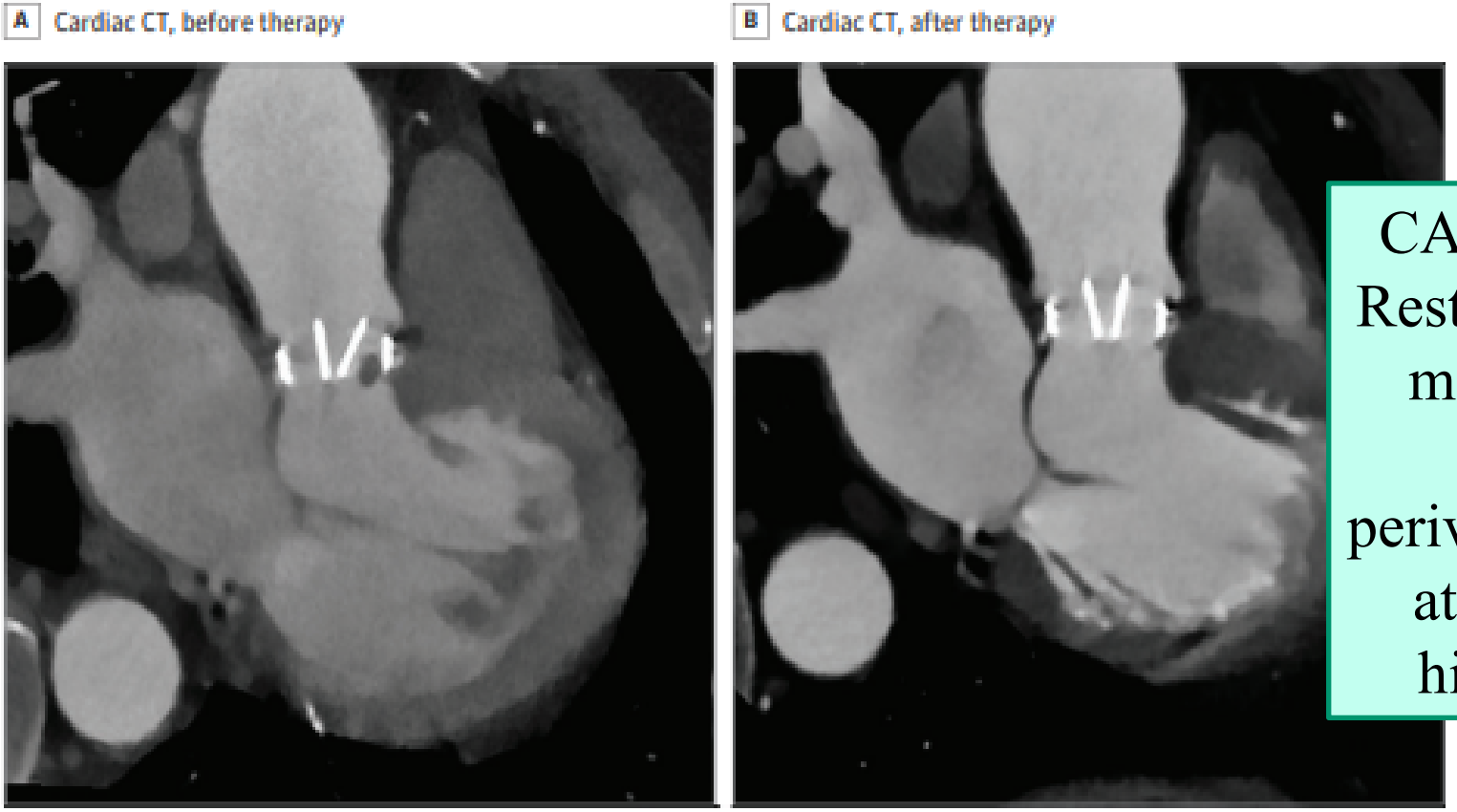
Detection of Mechanical Prosthetic Valve Dysfunction

Manuela Muratori, MD[a,*], Laura Fusini, MD[a], Sarah Ghulam Ali, MD[a], Giovanni Teruzzi, MD[a], Nicoletta Corrieri, MD[a], Paola Gripari, PhD, MD[a], Massimo Mapelli, MD[a], Andrea Annoni, MD[a], Gloria Tamborini, MD[a], Mark G. Rabbat, MD[b,c], Gianluca Pontone, MD[a], Francesco Alamanni, MD[a,d], Piero Montorsi, MD[a,d], and Mauro Pepi, MD[a]

Am J Cardiol 2021



In pts with a clinical suspicion of PVD, the combined model of **TTE + F offers incremental value over TTE or F alone**. This multimodality imaging approach provides prompt identification of pts who may require further imaging assessment and/or closer follow up.



CARDIAC CT
Restricted leaflet mobility and irregular perivalvular mass at the leaflet hinge point.

Figure. Prosthetic mechanical aortic valve thrombosis. A, Cardiac electrocardiogram-gated computed tomography (CT) studies of a prosthetic mechanical aortic valve with restricted leaflet mobility and an irregular perivalvular mass at the leaflet hinge point, suggestive of obstructive valve thrombosis. B, Follow-up cardiac CT 3 days later showed normal leaflet motion and resolution of the thrombus.

Prosthetic Mechanical Aortic Valve Thrombosis Joao Boavida, MD; Espen Ruud, MD; Haseem Ashraf, MD, PhD

JAMA Cardiology September 2022

Subclinical prosthetic biological valve thrombosis.

Early biological valve failure: thrombosis, rejection or endocarditis?

- **Bioprosthetic heart valves**
  - **Human tissue valves**
    - **Allografts**
      Cadaveric aortic valve
    - **Autografts**
      Ross procedure
  - **Xenografts**

    - **Stented**

      Medtronic Mosaic

      CE Perimount

      - **Porcine**
        CE SAV
        Medtronic Hancock II
        Medtronic Mosaic
        Abbott Biocor
        Abbott Epic
      - **Pericardial**
        CE PERIMOUNT line
        Sorin Mitroflow PRT
        Abbott Trifecta
        Avalus Medtronic
    - **Stentless**
      - **Porcine**
        Abbott Toronto SPV
        Medtronic Freestyle
      - **Pericardial**
        Sorin Solo Smart
    - **Sutureless**
      - **Sutureless**
        Edwards INTUITY Elite
        Sorin Perceval S

  - **Transcatheter heart valves**
    - **First generation iterations**
      Edwards SAPIEN
      Edwards SAPIEN XT
      Medtronic CoreValve
    - **Newer generation Devices**
      Edwards SAPIEN 3
      Medtronic CoreValve Evolut R
      Medtronic CoreValve Evolut Pro
      Boston Scientific Lotus
      Abbott Portico
      Boston Scientific ACURATE neo
      Edwards Centera
      JenaValve

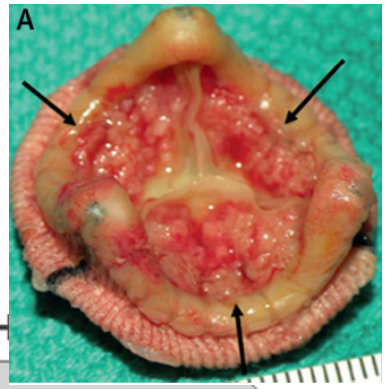
Early biological valve failure: thrombosis, rejection or endocarditis?

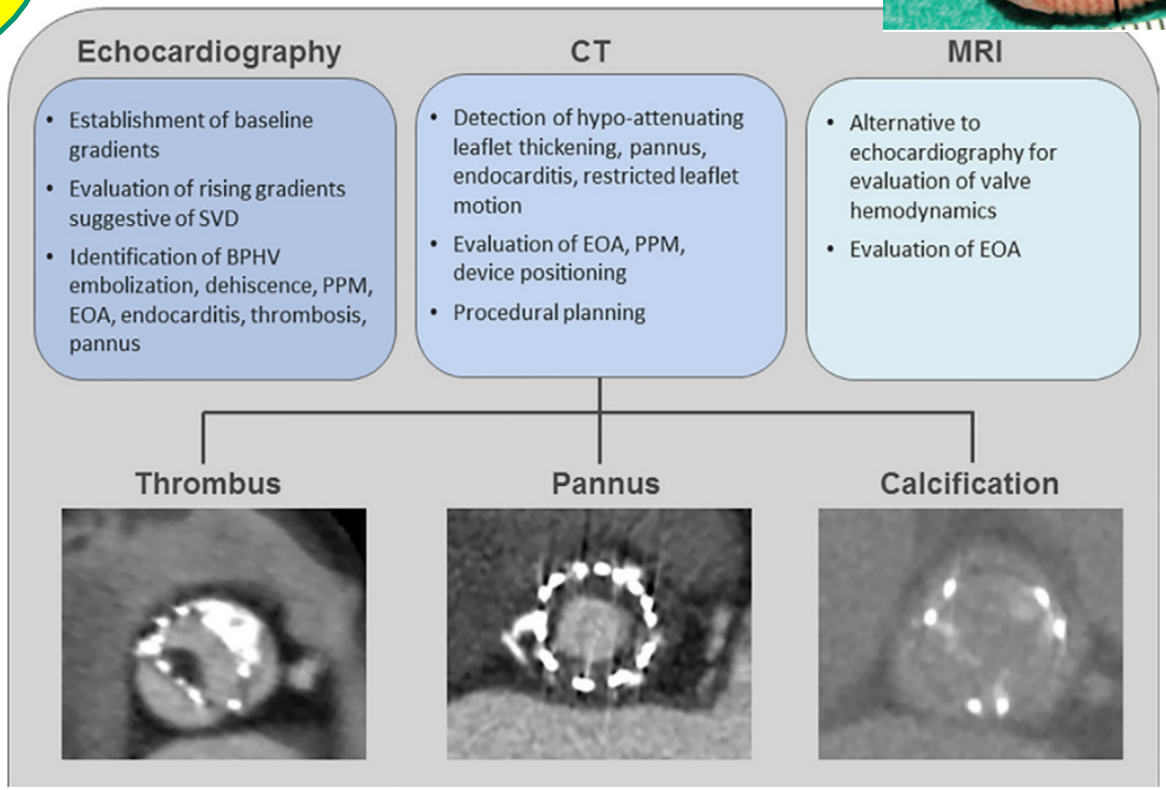
The differential diagnosis is difficult and a comprehensive multimodality Approach is very usefull

DIAGNOSTIC CLUE

ECHO: Rising gradients; Visualization thrombus Cusp Thickening Reduced mobility

CT: hypo-attenuating leaflet thickening, pannus..

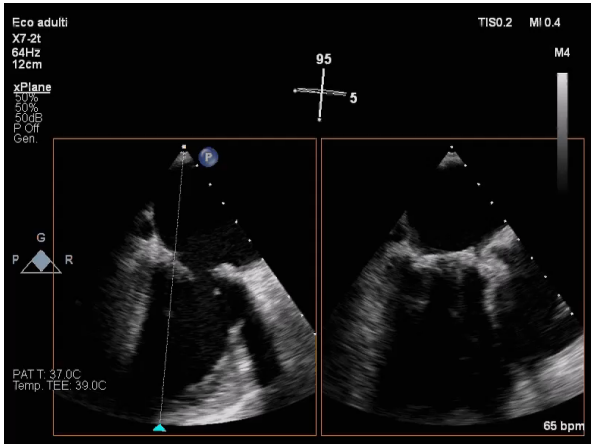


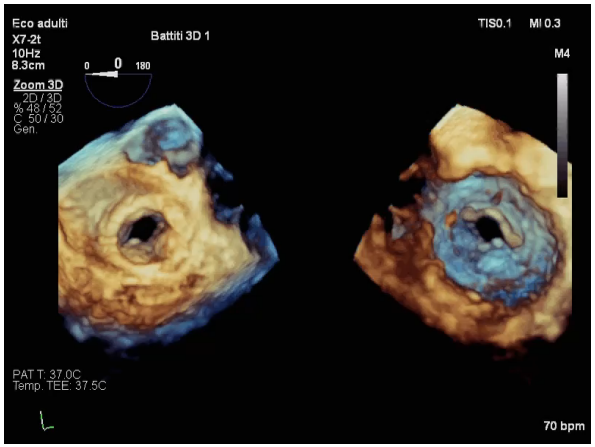


Radiology: Cardiothoracic Imaging 2019

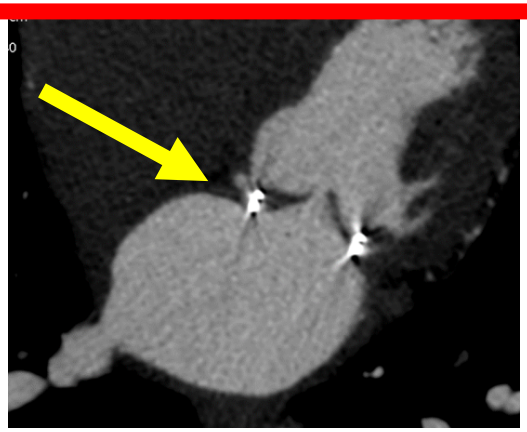
Early biological valve failure: Mitral Prosthetic Thrombosis

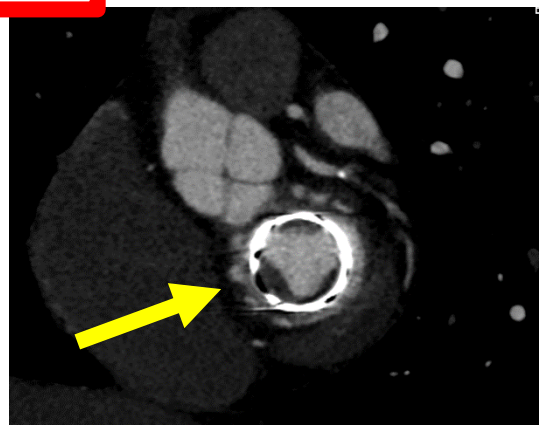
- F, 59 years,
- 2019: MVR (Magna 27)
- FAP -> NAO
- 2021: MVR dysfunction at TTE
- Blood cultures: negative
- TEE: valv thrombosis ?
- CT : valvular Thrombosis

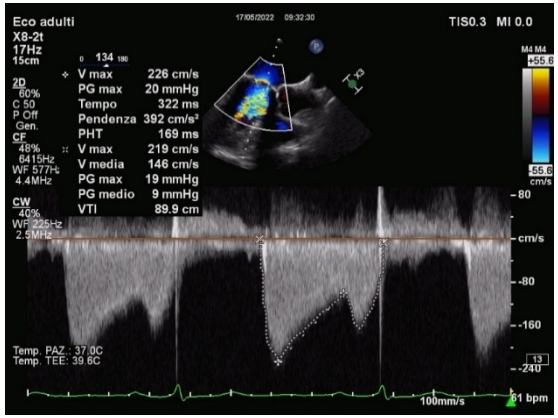




Mean Gradient 9 mmHG



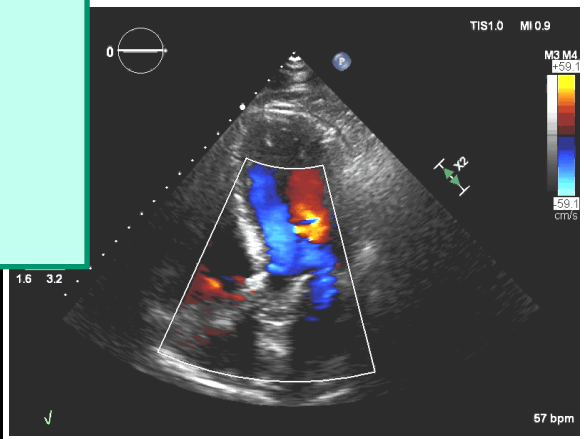


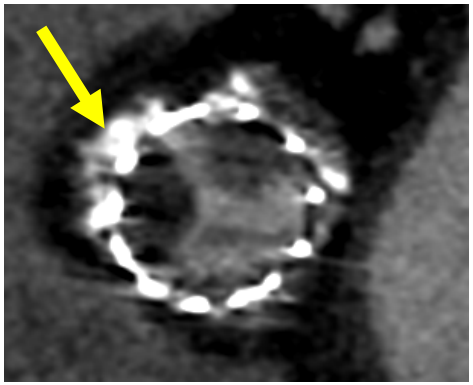


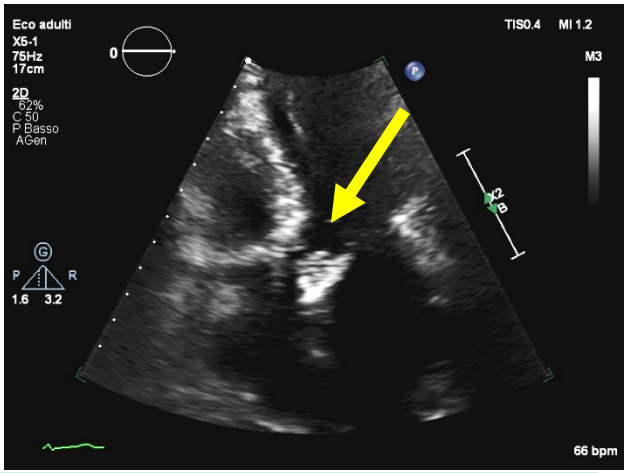
Early biological valve failure: Subclinical Valve Thrombosis

Subclinical valve thrombosis may uphold an immune response in biological heart valves, potentially contributing to their dysfunction

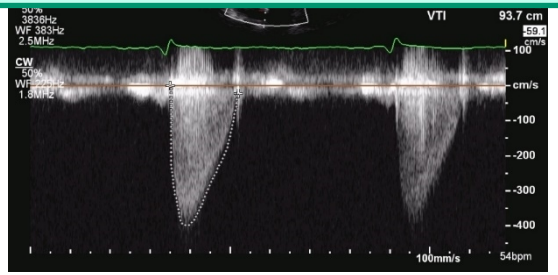
TAVR:
High gradients,
CT: thrombosis







Mean gradient: 34 mmHG



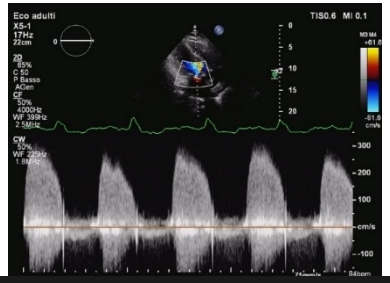
Early biological valve failure: Mitral Prosthetic Thrombosis

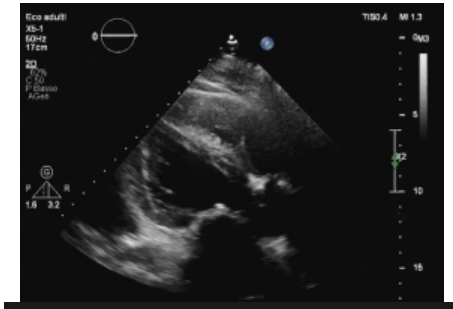
- M, 72 years,
- 2015: MVR (St Jude 31) + CABG
- 2019: FAP, TIA and Dyspnea
- 2021: MVR dysfunction at TTE
- Blood cultures: negative
- TEE: valvular an atrial thrombosis

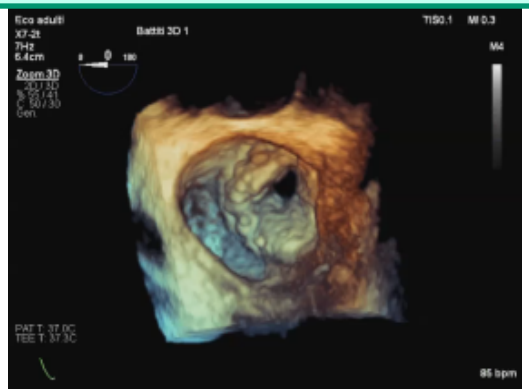
Why do we need early recognition and treatment?

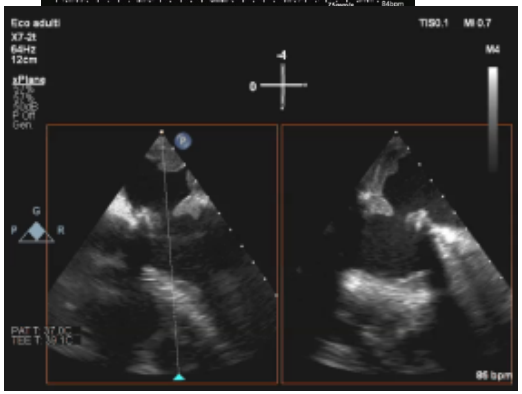
Rapid clinical deterioration

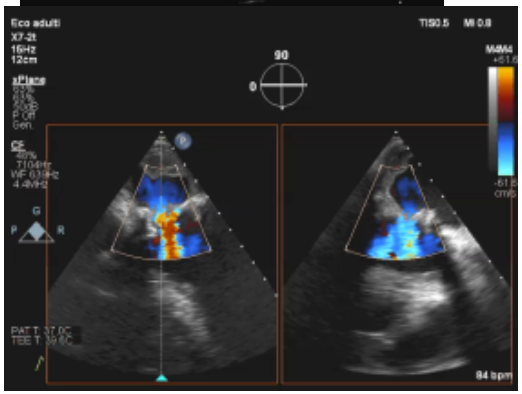
Mitral CASE

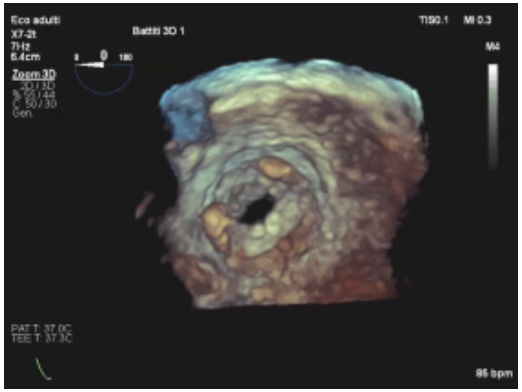












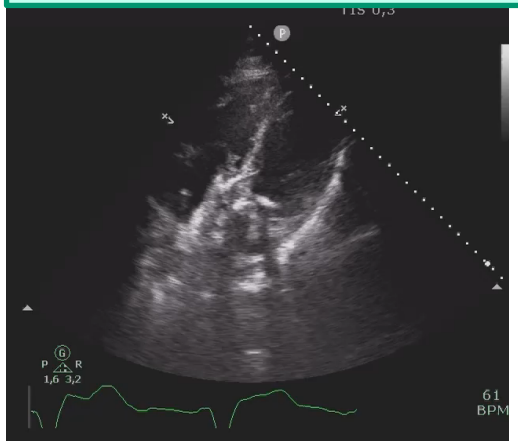
Early biological valve failure: Aortic Prosthetic Valve Thrombosis

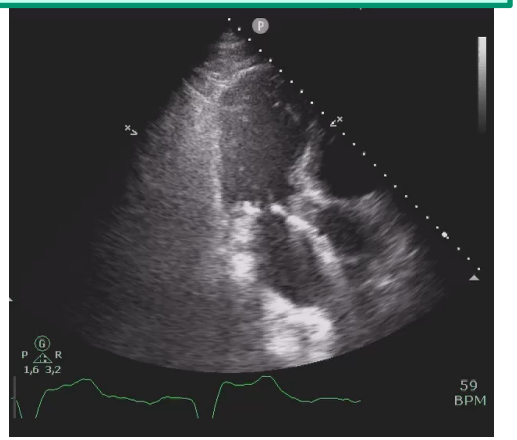
- M, 82 years,
- 2018: TAVR (ES 26)
- 2018: FA->NAO
- 3/2020: interstitial pneumonia Sars-Cov 2
- TTE: aortic prosthetic valve thrombosis
- Ictus and exitus

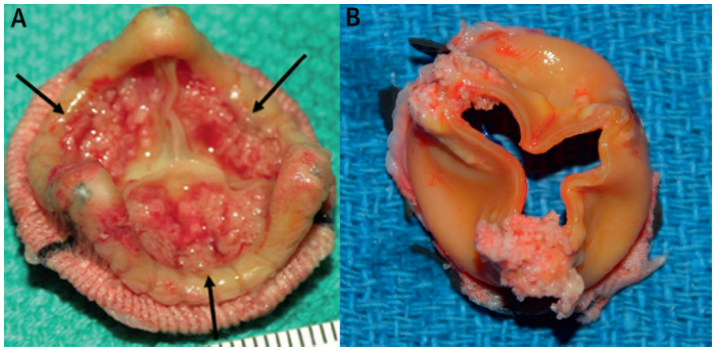
Why do we need early recognition and treatment?

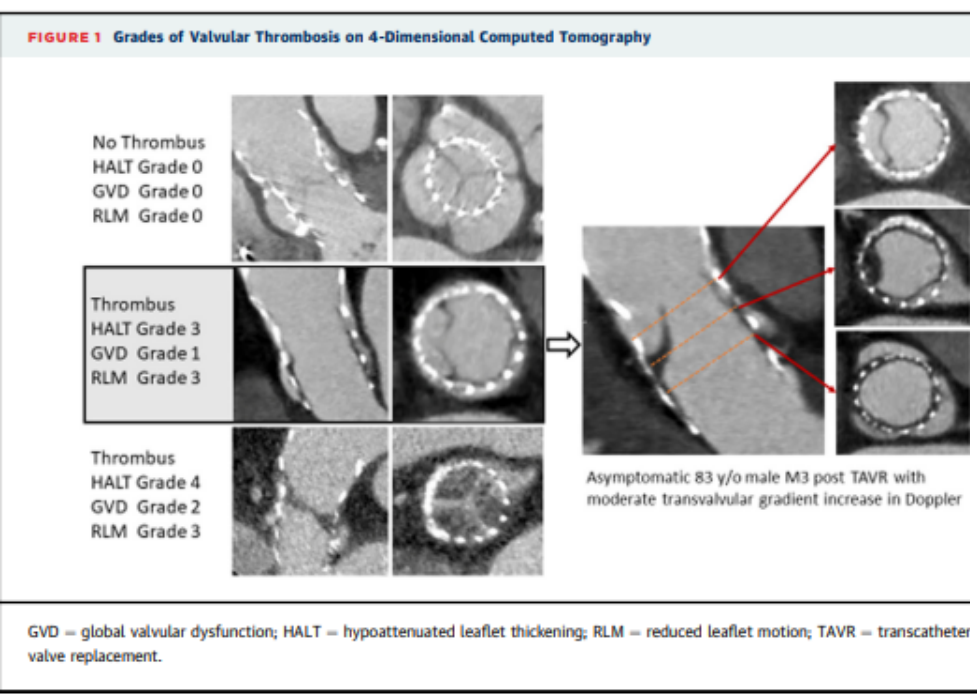
Rapid clinical deterioration

Aortic CASE









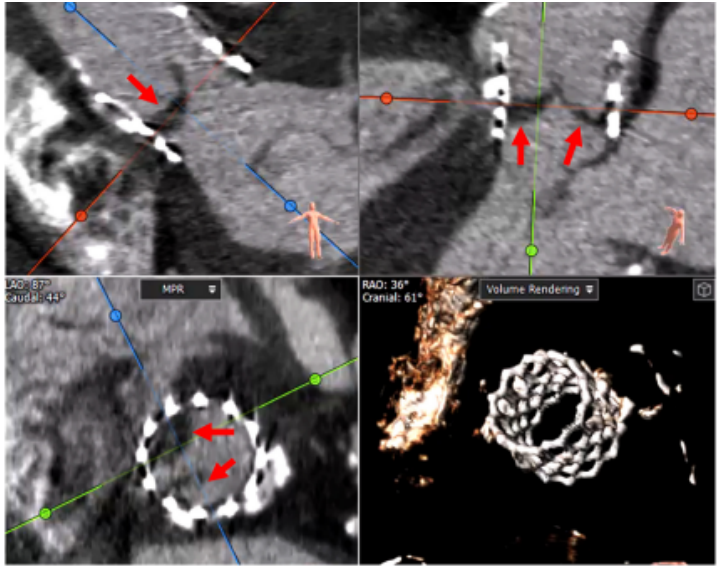


Fig. 3. Typical 4D-CT appearance of bioprosthetic thrombosis.
This patient presented with an acute myocardial infarction 9 months after transcatheter aortic valve replacement with a 26 mm Sapien 3 prosthesis. An elevated prosthetic gradient was suspicious for valve thromb… cusps (arrows), as well as reduced leaflet motion (Movie 2).

Apixaban as a single antithrombotic strategy after successful TAVR reduces the risk for valve thrombosis in pts without established indications for longterm anticoagulation at the cost of a nonsignificantly higher rate of thromboembolic and bleeding events

Montalescot et al JACC: CARDIOVASCULAR INTERVENTIONS 2022

Apixaban and Valve Thrombosis After TAVR

VKA are recommended in hemodynamically stable patients with BPVT; NOACs also seem effective in case series and apixaban had comparable safety to warfarin in the Partner 3 trial. Whether subclinical BPVT warrants preventive therapy remains a subject of debate

Progress in Cardiovascular Diseases (2022)

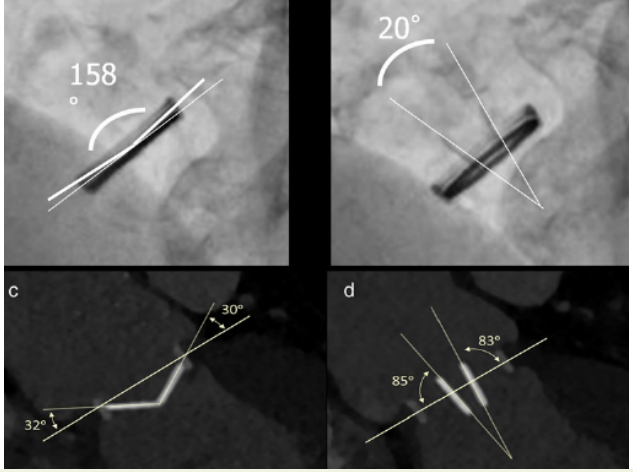
European Heart Journal - Cardiovascular Imaging Advance Access published May 3, 2016

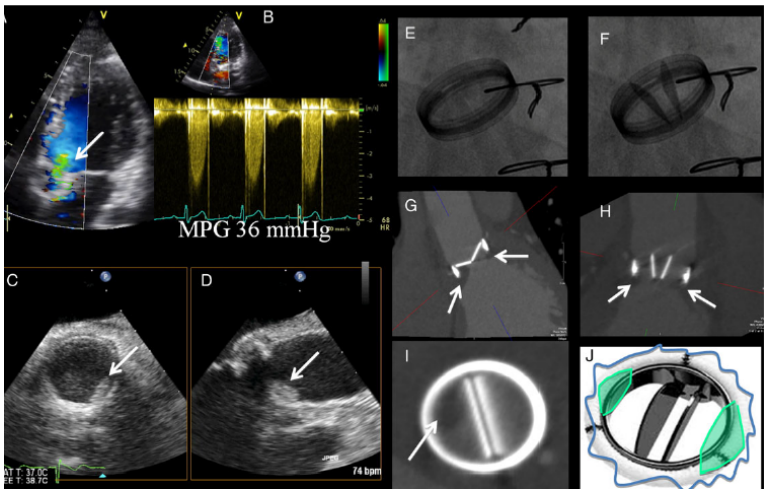
European Heart Journal – Cardiovascular Imaging
doi:10.1093/ehjci/jew025

REVIEW

Recommendations for the imaging assessment of prosthetic heart valves: a report from the European Association of Cardiovascular Imaging endorsed by the Chinese Society of Echocardiography, the Inter-American Society of Echocardiography, and the Brazilian Department of Cardiovascular Imaging†

Patrizio Lancellotti[1,2*], Philippe Pibarot[3,4], John Chambers[5], Thor Edvardsen[6], Victoria Delgado[7], Raluca Dulgheru[1], Mauro Pepi[8], Bernard Cosyns[9], Mark R. Dweck[10], Madalina Garbi[11], Julien Magne[12,13], Koen Nieman[14,15], Raphael Rosenhek[16], Anne Bernard[17,18], Jorge Lowenstein[19], Marcelo Luiz Campos Vieira[20,21], Arnaldo Rabischoffsky[22], Rodrigo Hernández Vyhmeister[23], Xiao Zhou[24], Yun Zhang[25], Jose-Luis Zamorano[26], and Gilbert Habib[27,28]





A comprehensive approach that integrates several parameters of valve morphology and function assessed with **2D/3D TTE and TEE** is a key to appropriately detect and quantitate PHV dysfunction. **Cinefluoroscopy, multidetector computed tomography, cardiac magnetic resonance imaging, and to a lesser extent, nuclear imaging** are complementary tools for the diagnosis and management of PHV complications