Evoluzioni 3D e nello speckle Tracking: sempre una promessa o una matura realtà diagnostica ?

Novità nel 3D trantoracico sul prolasso mitralico

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Dpt Cardiovascular Sciences.
University of Milan
ITALY

Centro Cardiologico Monzino

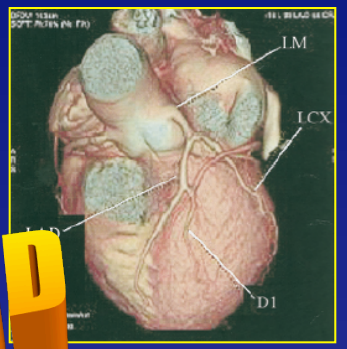
Napoli 2015

IMAGING CARDIOVASCOLARE

2D O 3D ?

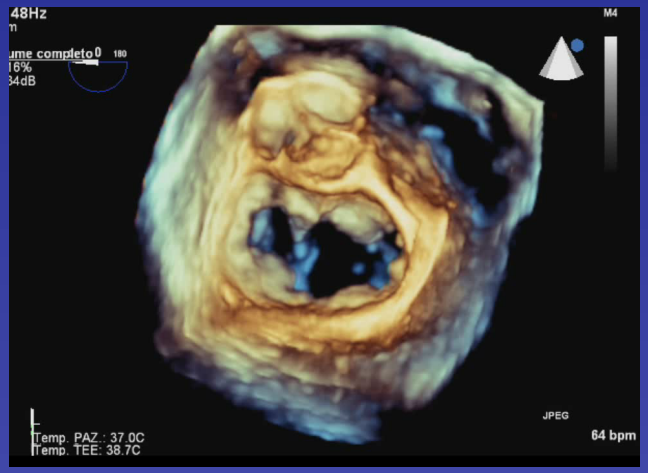
MRI

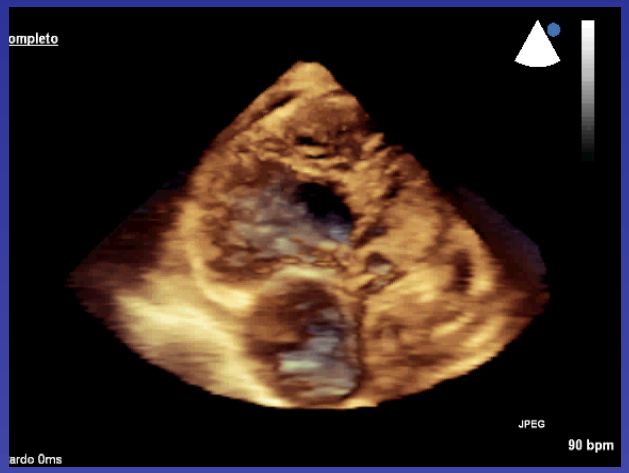
TAC

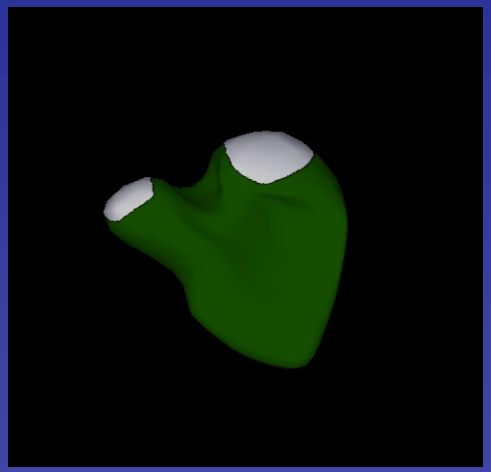


Lusso o Necessità

Morfologia e funzione sono 3D

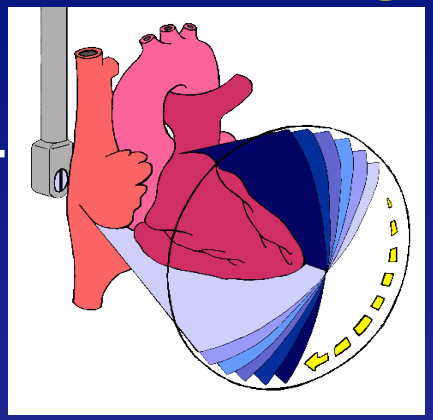


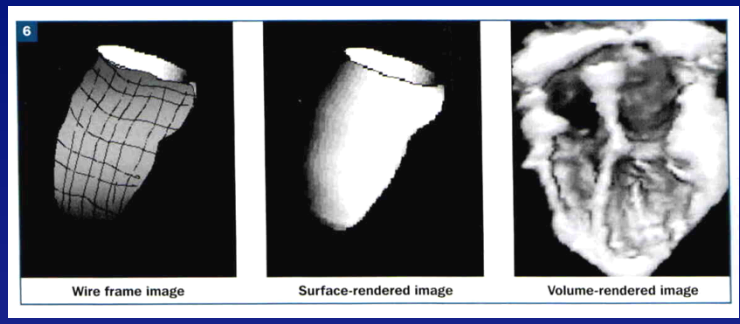




Historical Background

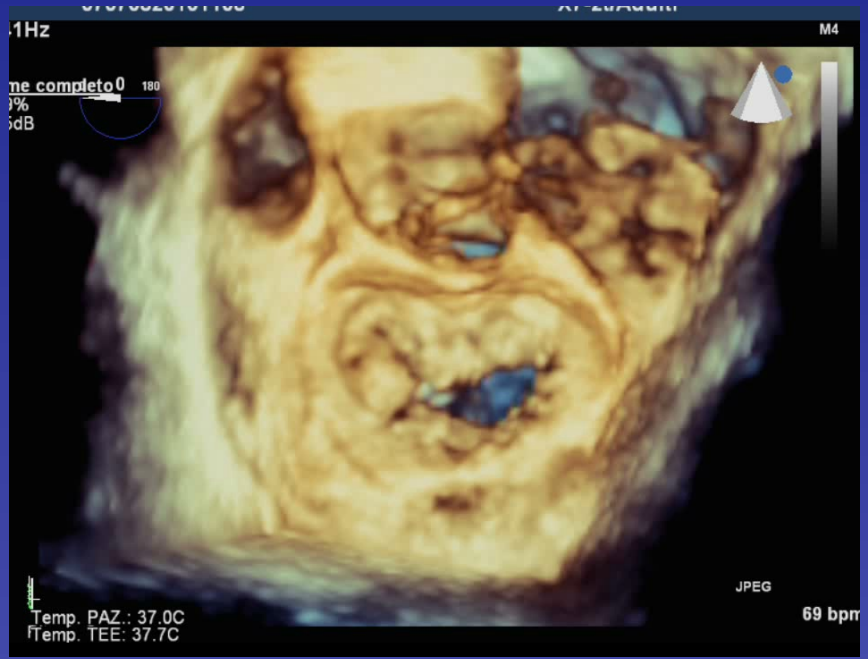
- Research activities.
- Nineties…..



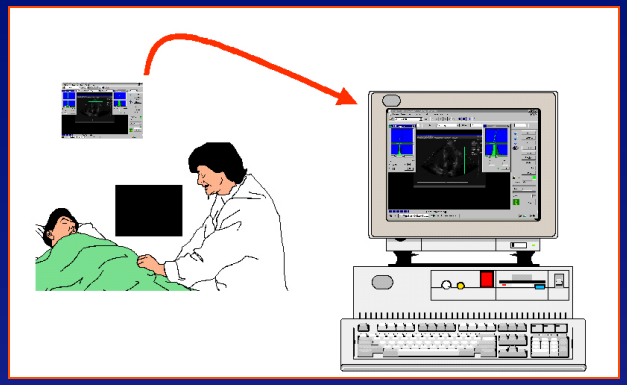


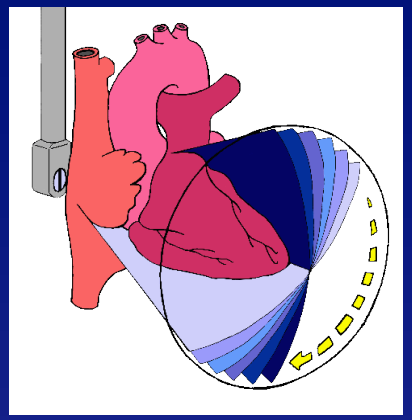
- 2002 Real Time 3D
- Trantoracico
- commerciale

- 2007 3D TEE

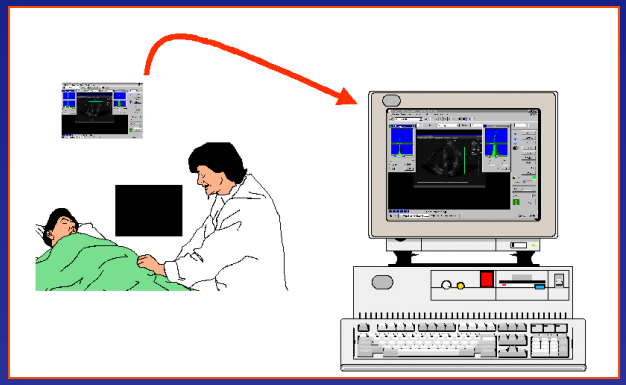


3D TEE
3DTTE

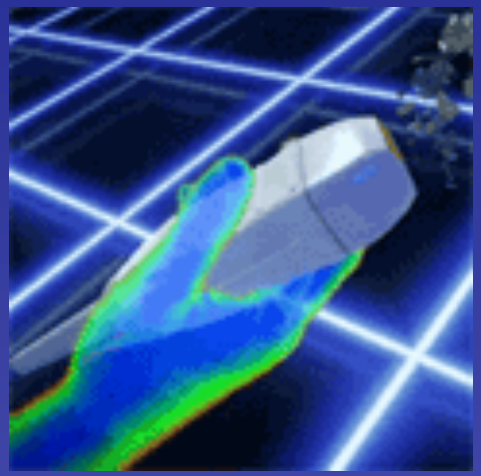




3D FREE-
HAND



3D LIVE
2002



“Free-hand” technique: Transmitter; Sensor/Receiver

Integrated circuit board combined with a position sensor attached to a commercial ultrasound transducer.
The positioning sensor device registers translation and rotation of the transducer thus determining its position and orientation.

Post-processing: transform acquired data to cartesian coordinate system. Interpolation of undersampled regions.

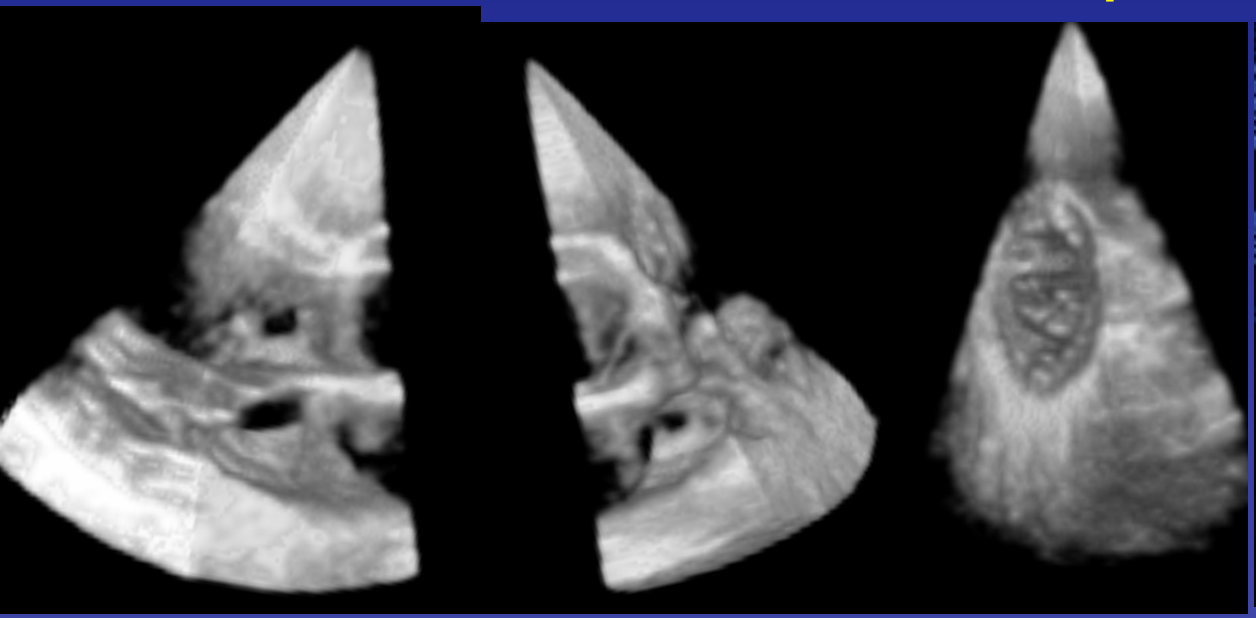
Initial experience with a new on-line transthoracic three-dimensional technique: assessment of feasibility and of diagnostic potential

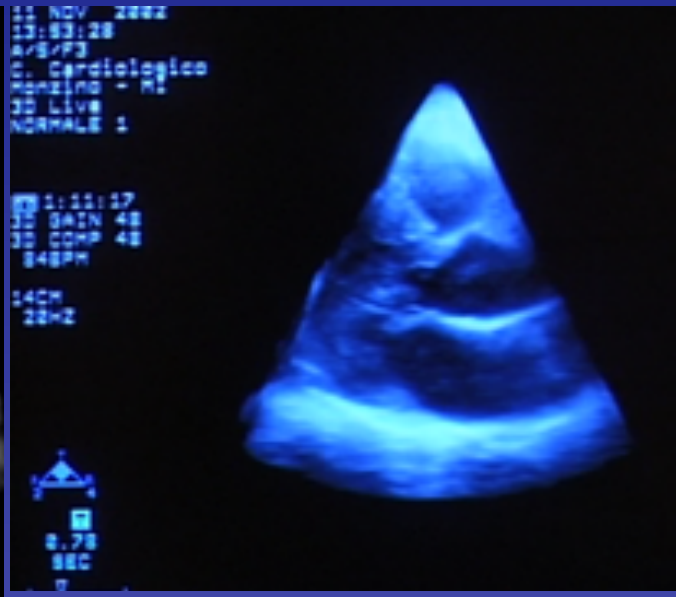
Mauro Pepi, Gloria Tamborini, GianLuca Pontone, Daniele Andreini, Giovanni Berna, Stefano De Vita, Anna Maltagliati

Centro Cardiologico Monzino, IRCCS, Milan, Italy

(Ital Heart J 2003; 4 (8)

- Clinical Trial in 83 adult patients



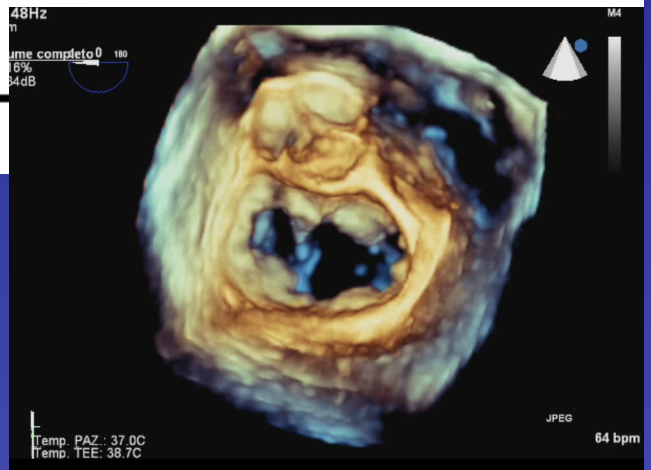


GUIDELINES AND STANDARDS

EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

Roberto M. Lang, MD, FASE,*‡ Luigi P. Badano, MD, FESC,†‡ Wendy Tsang, MD,* David H. Adams, MD,* Eustachio Agricola, MD,† Thomas Buck, MD, FESC,† Francesco F. Faletra, MD,† Andreas Franke, MD, FESC,† Judy Hung, MD, FASE,* Leopoldo Pérez de Isla, MD, PhD, FESC,† Otto Kamp, MD, PhD, FESC,† Jaroslaw D. Kasprzak, MD, FESC,† Patrizio Lancellotti, MD, PhD, FESC,† Thomas H. Marwick, MBBS, PhD,* Marti L. McCulloch, RDCS, FASE,* Mark J. Monaghan, PhD, FESC,† Petros Nihoyannopoulos, MD, FESC,† Natesa G. Pandian, MD,* Patricia A. Pellikka, MD, FASE,* Mauro Pepi, MD, FESC,† David A. Roberson, MD, FASE,* Stanton K. Shernan, MD, FASE,* Girish S. Shirali, MBBS, FASE,* Lissa Sugeng, MD,* Folkert J. Ten Cate, MD,† Mani A. Vannan, MBBS, FASE,* Jose Luis Zamorano, MD, FESC, FASE,† and William A. Zoghbi, MD, FASE*, *Chicago and Oak Lawn, Illinois; Padua and Milan, Italy; New York, New York; Essen and Hannover, Germany; Lugano, Switzerland; Boston, Massachusetts; Madrid, Spain; Amsterdam and Rotterdam, The Netherlands; Lodz, Poland; Liege, Belgium; Cleveland, Ohio; Houston, Texas; London, United Kingdom; Rochester, Minnesota; Charleston, South Carolina; New Haven, Connecticut; Morrisville, North Carolina*

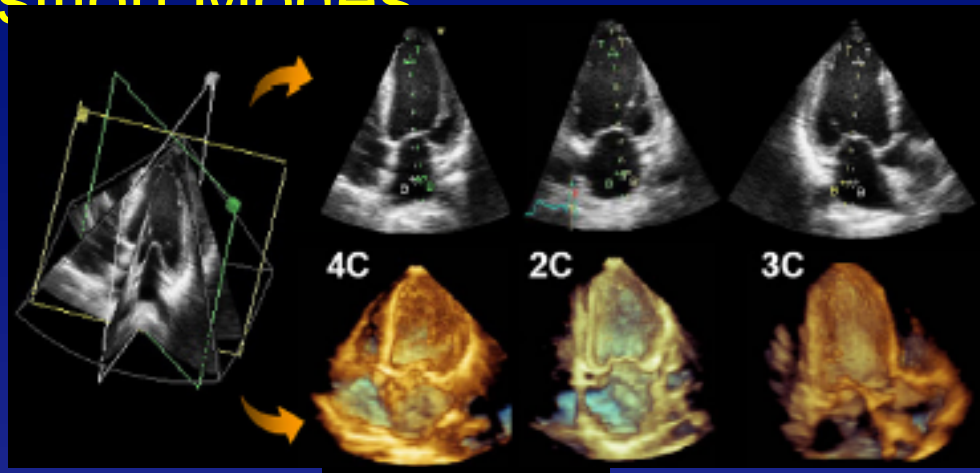
(J Am Soc Echocardiogr 2012;25:3-46.)



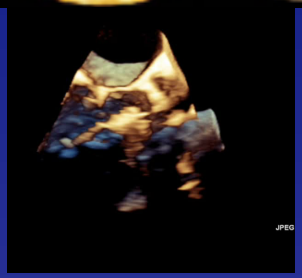
2012

Data Acquisition Modes

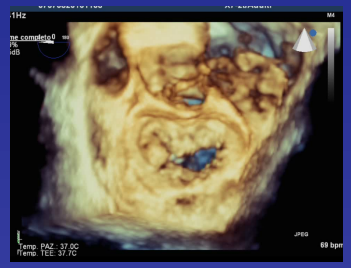
- Simultaneous Multiplane
- Mode.



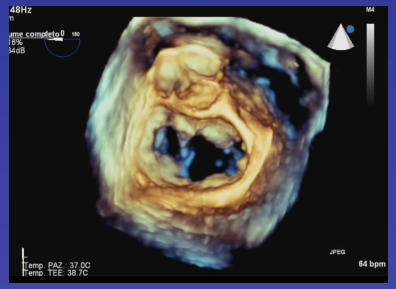
- Real-Time 3D Mode—Narrow Sector



- Focused Wide Sector—“ZOOM”.



- Full Volume—Gated Acquisition.



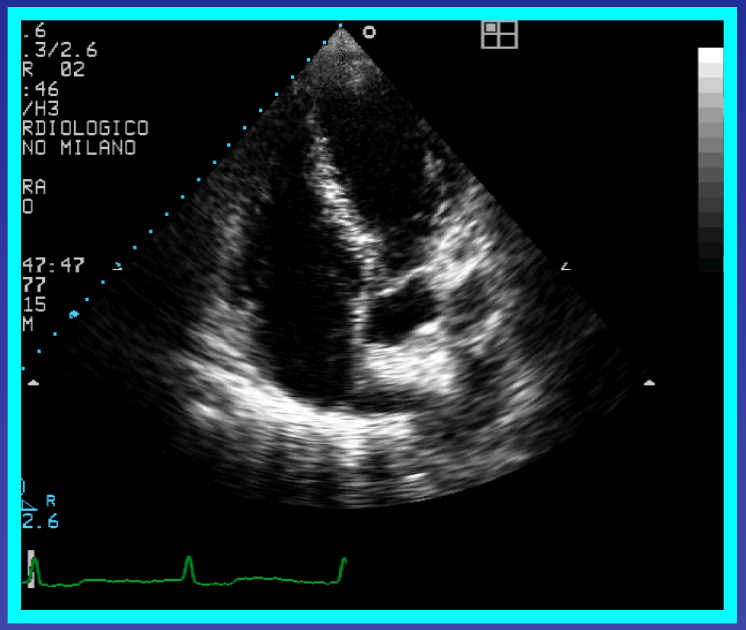
Protocollo 3D

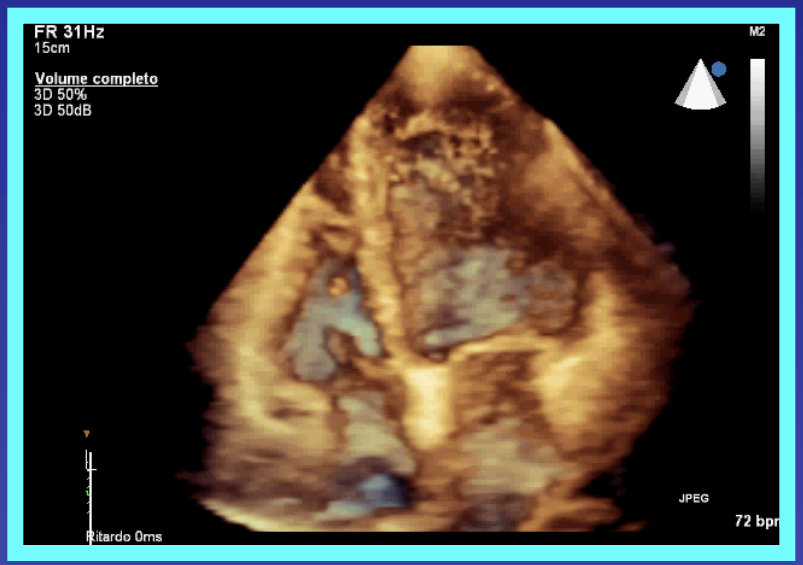
transtoracico

?

2002: Live 3D TTE

Sonde dedicate





FLOW-CHART del PROTOCOLLO TTE

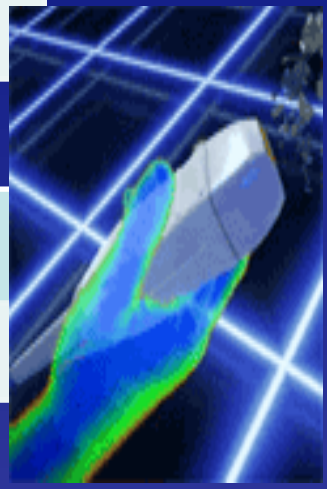
ECO 3D mai alternativo al 2D ma complementare

Protocollo standard

ECO 2D — sempre

Protocollo standard

Color/Doppler — sempre



Sonde Dedicate 3D

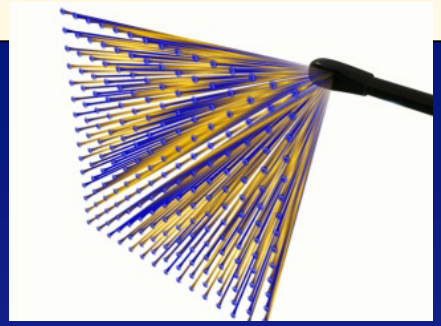
Protocollo specifico per 3D

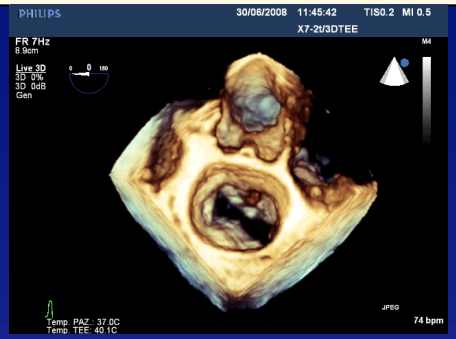
3D TT — Indicazioni

MV, RV, LV, Ao etc

MAINLY INTRAOPERATIVE/Monitoring interventional procedures

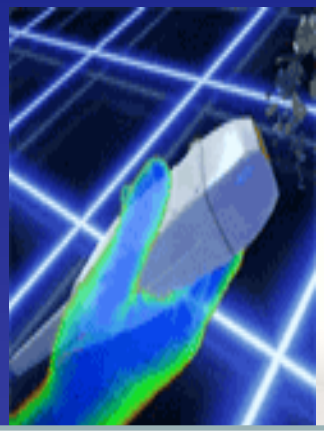
REAL TIME TEE 3D





MAINLY ROUTINE TRANSTHORACIC

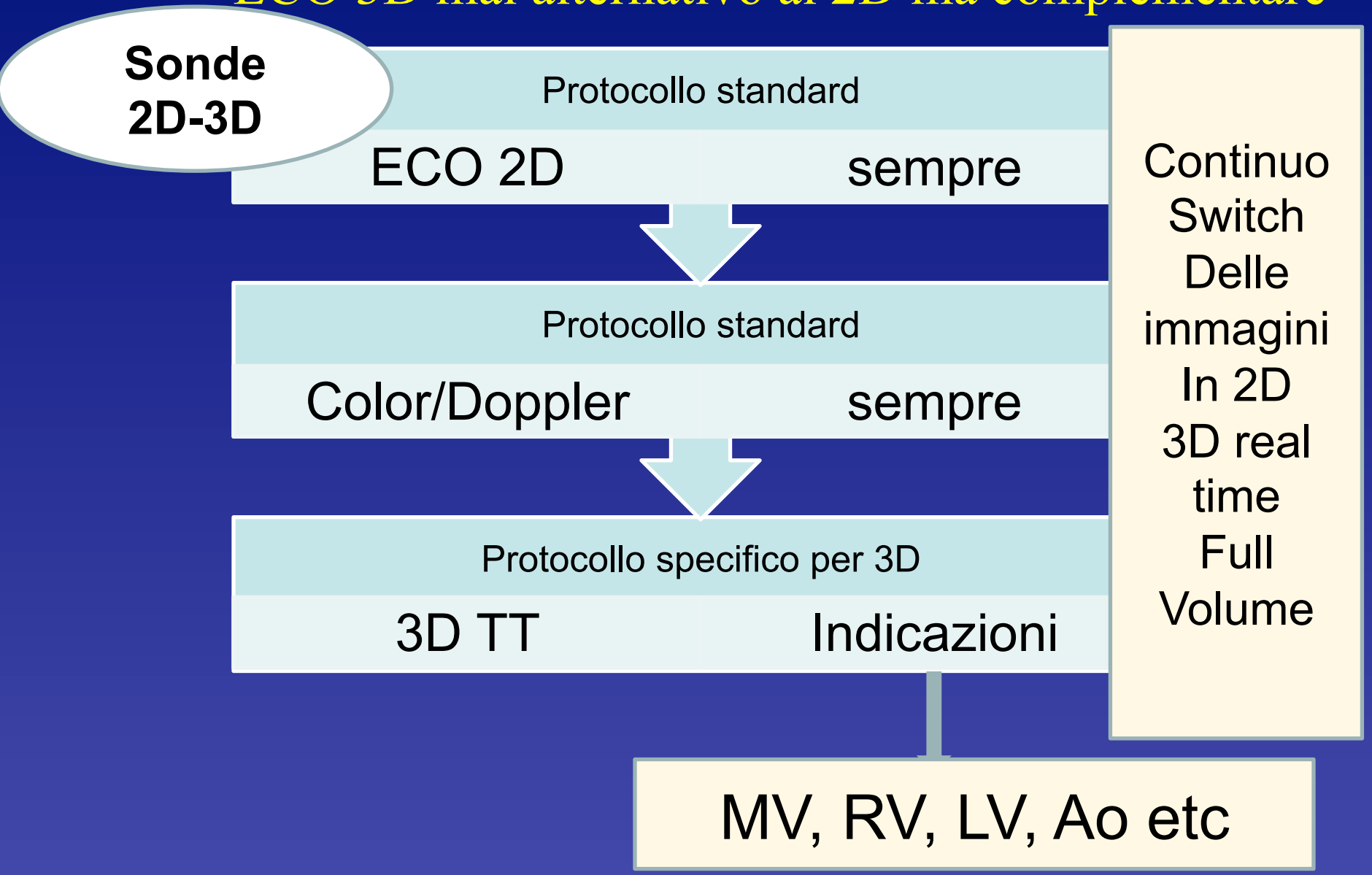
REAL TIME TT 3D



3,000 elements and breakthrough PureWave xMATRIX technology, the X5-1 supports virtually any cardiac ultrasound exam, including 3D, 2D, color flow, M-mode, PW/CW Doppler, Tissue Doppler imaging, and contrast-enhanced exams.

Sonde Switch 2D/3D

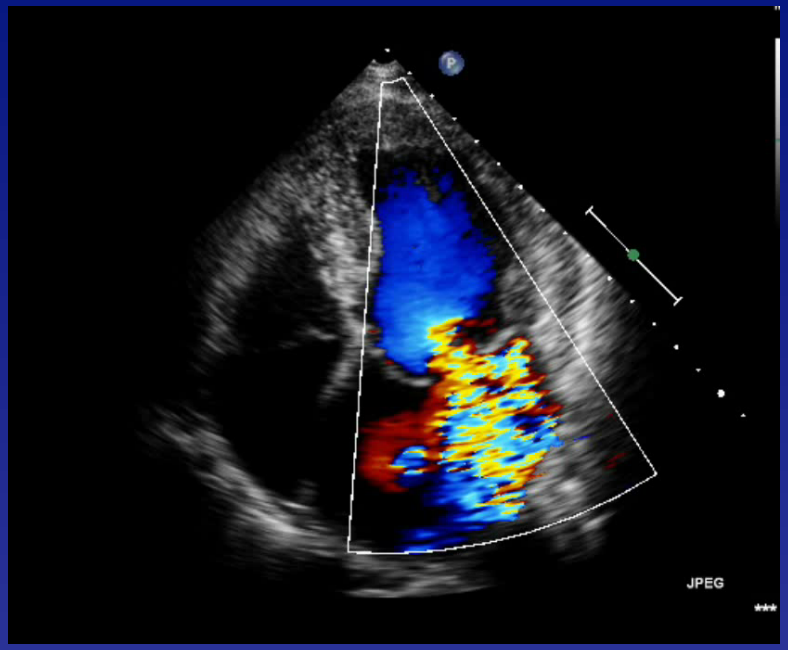
FLOW-CHART del PROTOCOLLO TEE
ECO 3D mai alternativo al 2D ma complementare



CAMPI APPLICATIVI DELL ECO 3D Transtoracico

- *PATOLOGIE CONGENITE*
- *MASSE CARDIACHE*
- ***VALVULOPATIE: prolasso mitralico***
- *FUNZIONE VENTRICOLARE SINISTRA*
- *FUNZIONE VENTRICOLARE DESTRA*
- *MONITORAGGI PROCEDURALI*

Severe MR in MV prolapse

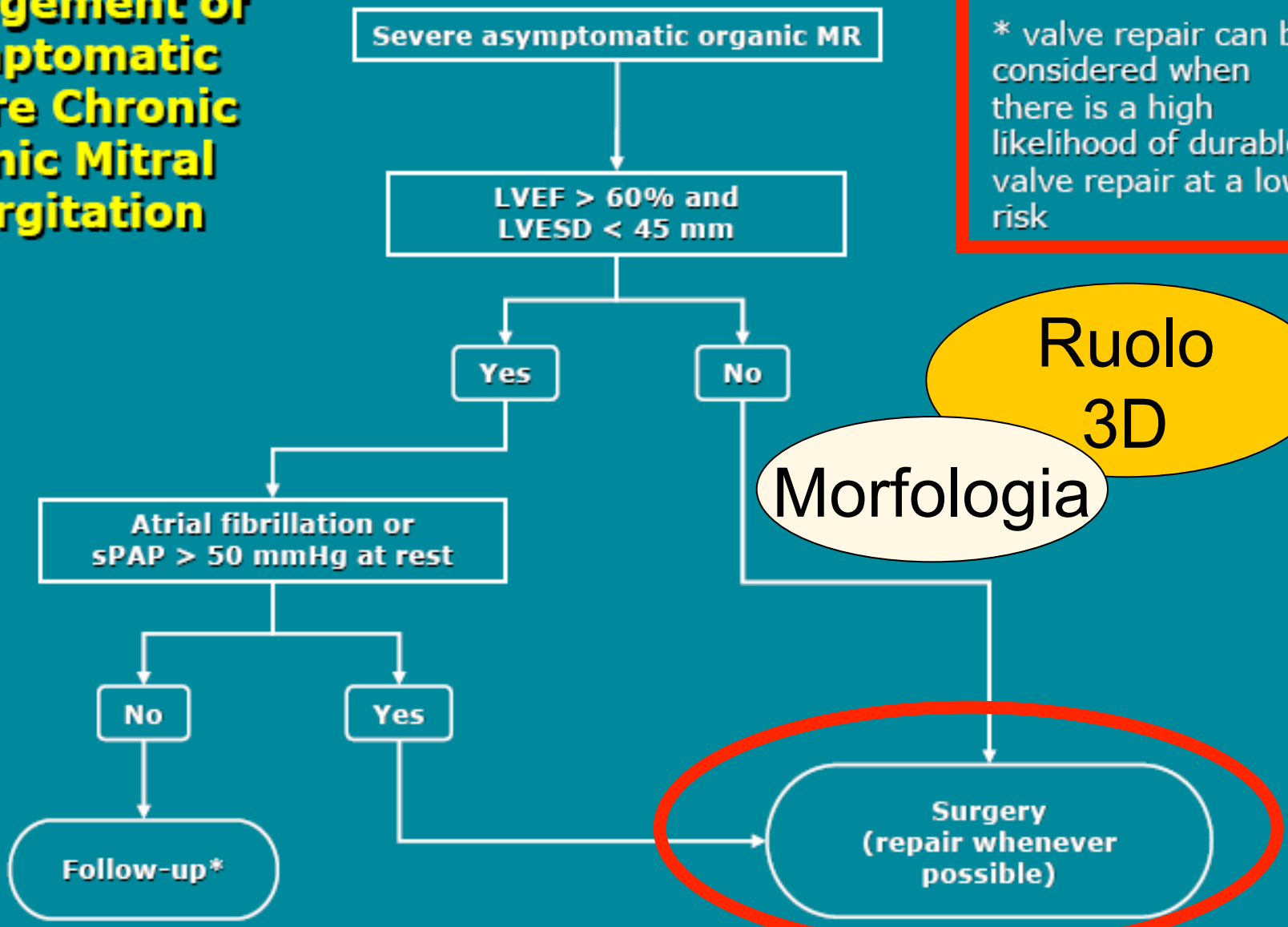


2D and Color-Doppler

Indication and timing
Of MV surgery

LV diameters, volumes and EF
Left atrial dimensions
Severity of MR
Pulmonary Systolic Pressure

Management of Asymptomatic Severe Chronic Organic Mitral Regurgitation



* valve repair can be considered when there is a high likelihood of durable valve repair at a low risk

Ruolo 3D

Morfologia

GUIDELINES AND STANDARDS

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Roberto M. Lang, MD, FASE,*‡ Luigi P. Badano, MD, FESC,†‡ Wendy Tsang, MD,* David H. Adams, MD,* Eustachio Agricola, MD,† Thomas Buck, MD, FESC,† Francesco F. Faletra, MD,† Andreas Franke, MD, FESC,† Judy Hung, MD, FASE,* Leopoldo Pérez de Isla, MD, PhD, FESC,† Otto Kamp, MD, PhD, FESC,† Jaroslaw D. Kasprzak, MD, FESC,† Patrizio Lancellotti, MD, PhD, FESC,† Thomas H. Marwick, MBBS, PhD,* Marti L. McCulloch, RDCS, FASE,* Mark J. Monaghan, PhD, FESC,† Petros Nihoyannopoulos, MD, FESC,† Natesa G. Pandian, MD,* Patricia A. Pellikka, MD, FASE,* Mauro Pepi, MD, FESC,† David A. Roberson, MD, FASE,* Stanton K. Shernan, MD, FASE,* Girish S. Shirali, MBBS, FASE,* Lissa Sugeng, MD,* Folkert J. Ten Cate, MD,† Mani A. Vannan, MBBS, FASE,* Jose Luis Zamorano, MD, FESC, FASE,† and William A. Zoghbi, MD, FASE*, *Chicago and Oak Lawn, Illinois; Padua and Milan, Italy; New York, New York; Essen and Hannover, Germany; Lugano, Switzerland; Boston, Massachusetts; Madrid, Spain; Amsterdam and Rotterdam, The Netherlands; Lodz, Poland; Liege, Belgium; Cleveland, Ohio; Houston, Texas; London, United Kingdom; Rochester, Minnesota; Charleston, South Carolina; New Haven, Connecticut; Morrisville, North Carolina*

(J Am Soc Echocardiogr 2012;25:3-46.)

3D echocardiography may be superior to 2DE techniques and even direct inspection during surgery for diagnosing the location and extent of complex mitral valve disease, especially when commissural pathology or clefts are present.

A Framework for Systematic Characterization of the Mitral Valve by Real-Time Three-Dimensional Transesophageal Echocardiography

Ernesto E. Salcedo, MD, Robert A. Quaife, MD, Tamas Seres, MD, and John D. Carroll, MD, *Denver, Colorado*

Table 1 Publications on 3D TEE of the MV

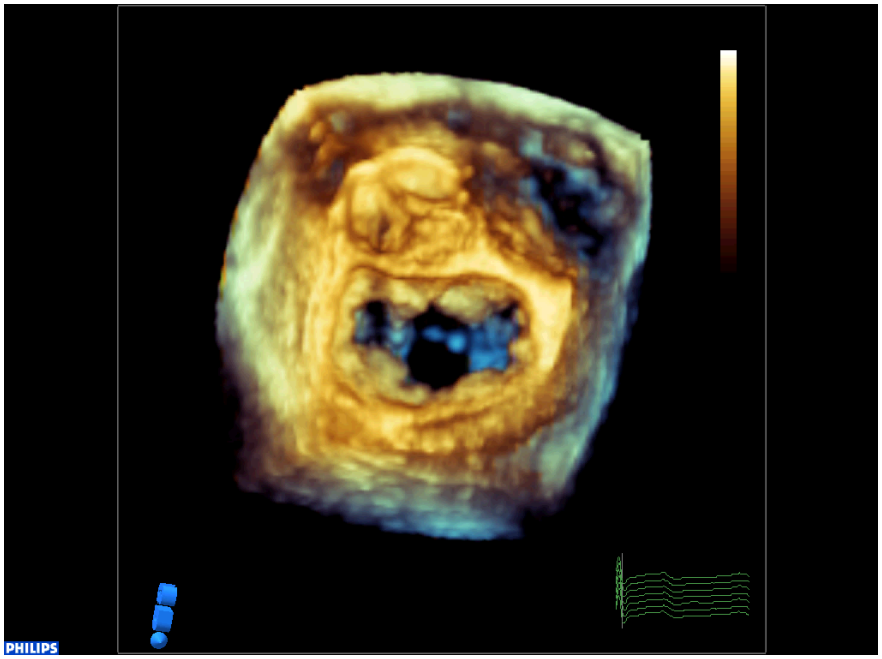
Reference	Population	Echocardiographic modalities	Assessment	Findings
Pepi et al[16]	112 patients with MVP and severe MR	2D and 3D TTE, 2D TEE, 3D TEE (reconstruction)	MV repair surgery	3D TEE superior on description of pathology; 95% accuracy
Valocik et al[18]	45 patients with MS	2D TTE, 2D TEE, 3D TEE (reconstruction)	Quantitative 3D echocardiography of MS	Funnel-like geometry may predict MS severity
Garcia-Orta et al[25]	81 patients with severe MR	2D TEE, 3D TEE (reconstruction)	MV repair surgery	3D better in A1 defects and commissures
Sugeng et al[14]	211 patients referred for TEE	2D TEE, 3D MTEE	Image quality of native valves	85%-91% visualization of all MV scallops
Sugeng et al[12]	40 prosthesis, 47 MV surgery	3D MTEE	Image quality, Surgical findings	Best for MVR; 96% surgical agreement
Grewal et al[27]	42 patients with MV repair	2D TEE, 3D TEE	Surgical inspection	3D TEE superior for P1, A2, A3, and bileaflet disease

MR, Mitral regurgitation; *MS*, mitral stenosis; *MTEE*, matrix-array TEE; *MV*, mitral valve; *MVP*, mitral valve prolapse; *MVR*, mitral valve prosthesis.

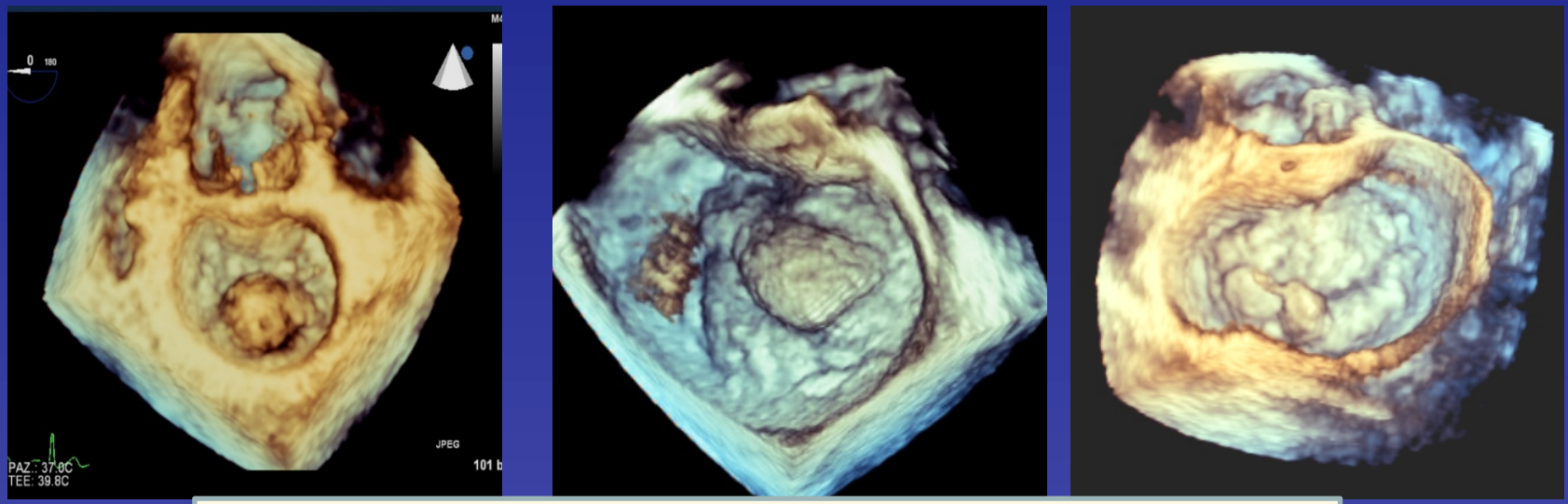
Journal of the American Society of Echocardiography
October 2009

Fibro-elastic-deficiency

Barlow'sDisease



Transthoracic 3D



Transesophageal 3D

Pre-operative evaluation of MV prolapse and the role of 3D Trasthoracic Echocardiography

Has real time 3D transthoracic echo a role in facilitating the clinical decision making process in asymptomatic patients with MV prolapse and severe MR ?

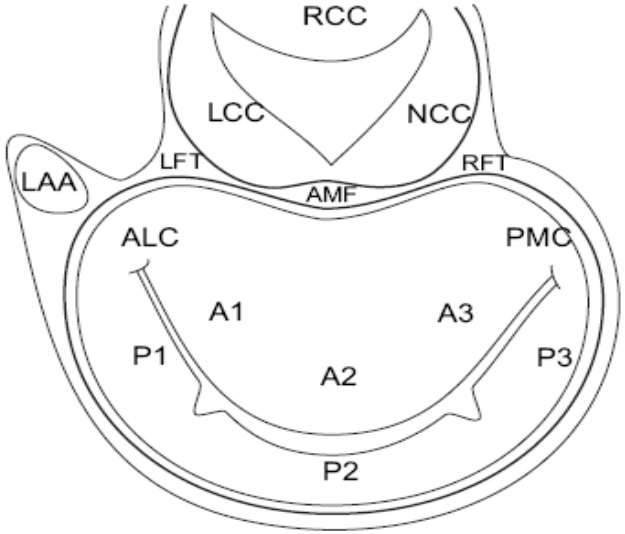


Figure 5 Diagram of the mitral valve as seen from the left atrium. The anterior leaflet and its 3 segments (A1, A2, and A3) are posterior (P) to the left coronary cusp (LCC) and noncoronary cusp (NCC) of the aortic valve and adjacent to the aortomitral fibrosa (AMF) and the left fibrous trigone (LFT) and right fibrous trigone (RFT). The anterolateral commissure (ALC) is next to the left atrial appendage (LAA) and the A1 P1 scallops. The posteromedial commissure (PMC) is next to the A3 and P3 scallops. *RCC*, Right coronary cusp.

Journal of the American Society of Echocardiography
October 2009

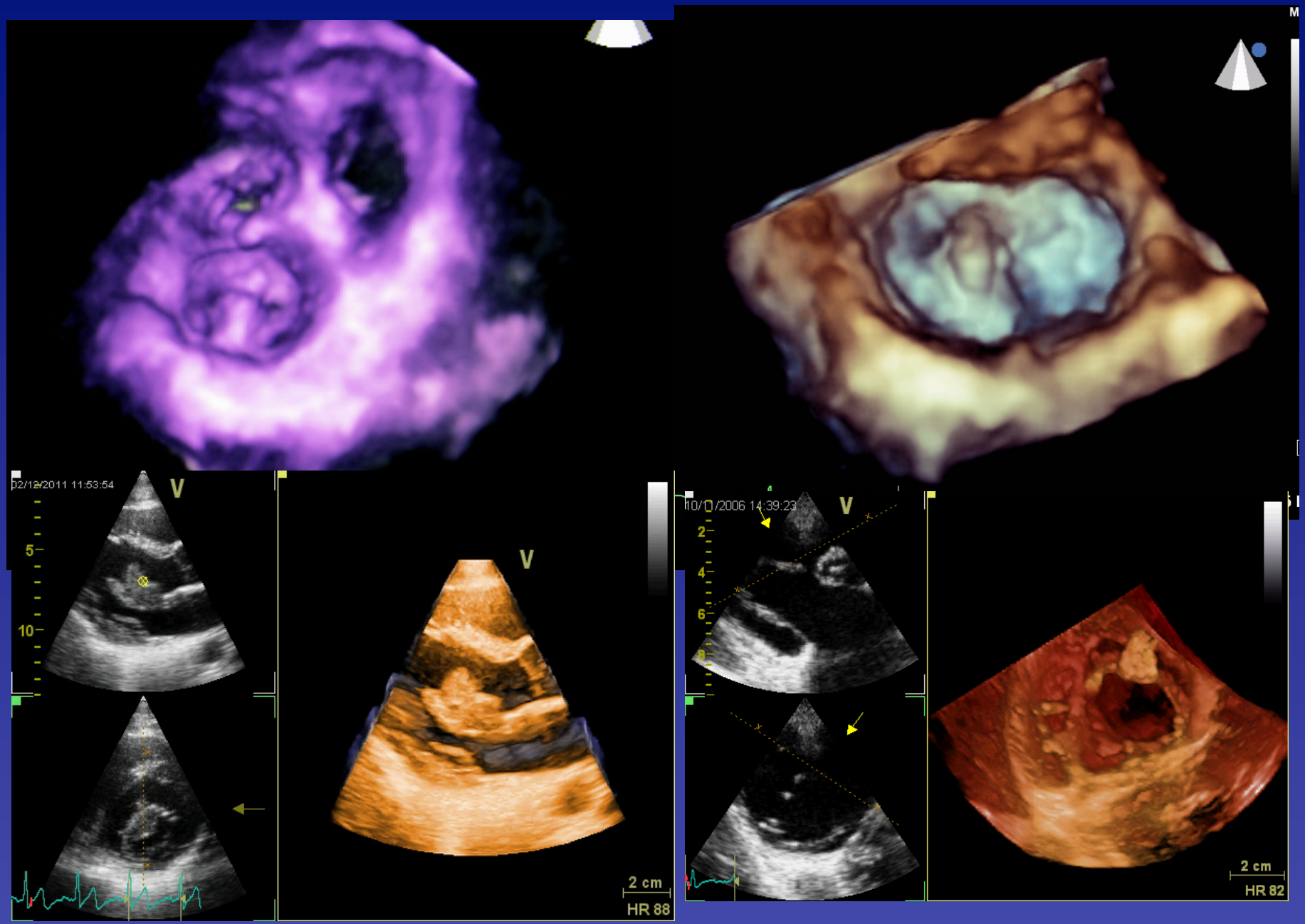
IMPORTANZA DIAGNOSI MORFOLOGICA 3D

Better evaluation of **morphologic abnormalities** and understanding of complex spatial orientation

Better **quantitative evaluation** (area and volume) (obviates any geometrical assumptions)

Facilitates **Training and Communication** between experts, non-experts and different specialists.

MVP basale 3D Transtoracico



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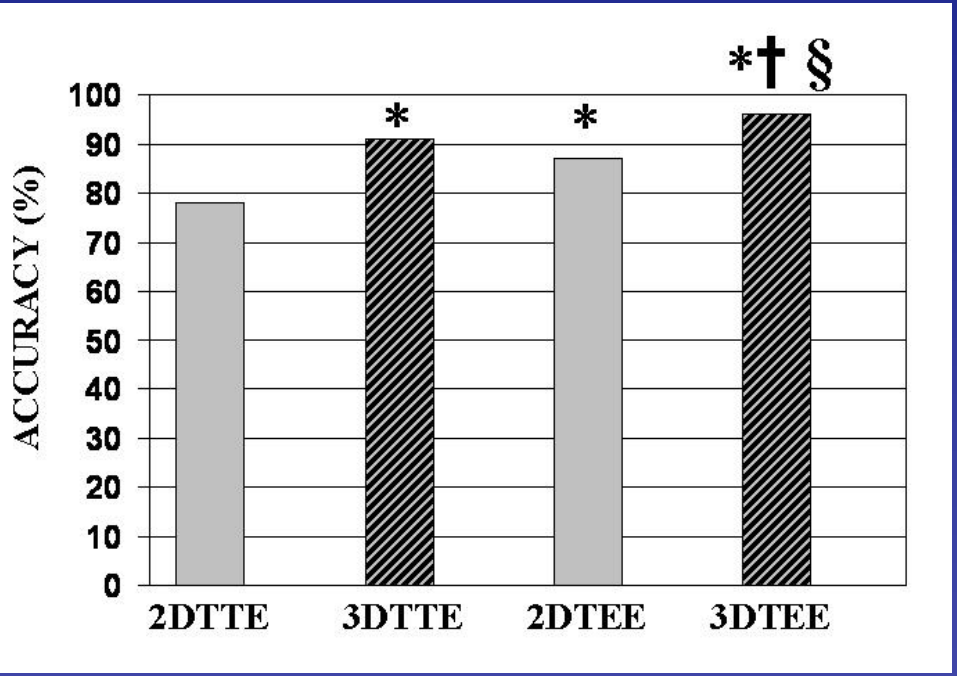
ISSN 0735-1097/06/$32.00
doi:10.1016/j.jacc.2006.02.079

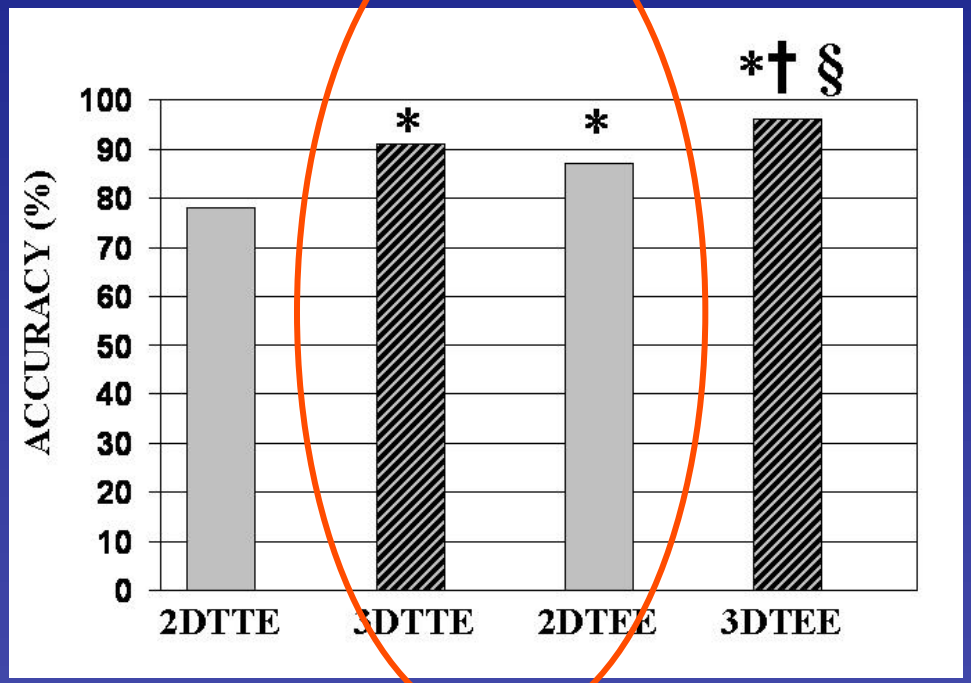
Head-to-Head Comparison of Two- and Three-Dimensional Transthoracic and Transesophageal Echocardiography in the Localization of Mitral Valve Prolapse

Mauro Pepi, MD, Gloria Tamborini, MD, Anna Maltagliati, MD, Claudia Agnese Galli, MD, Erminio Sisillo, MD, Luca Salvi, MD, Moreno Naliato, MD, Massimo Porqueddu, MD, Alessandro Parolari, MD, Marco Zanobini, MD, Francesco Alamanni, MD

Milan, Italy



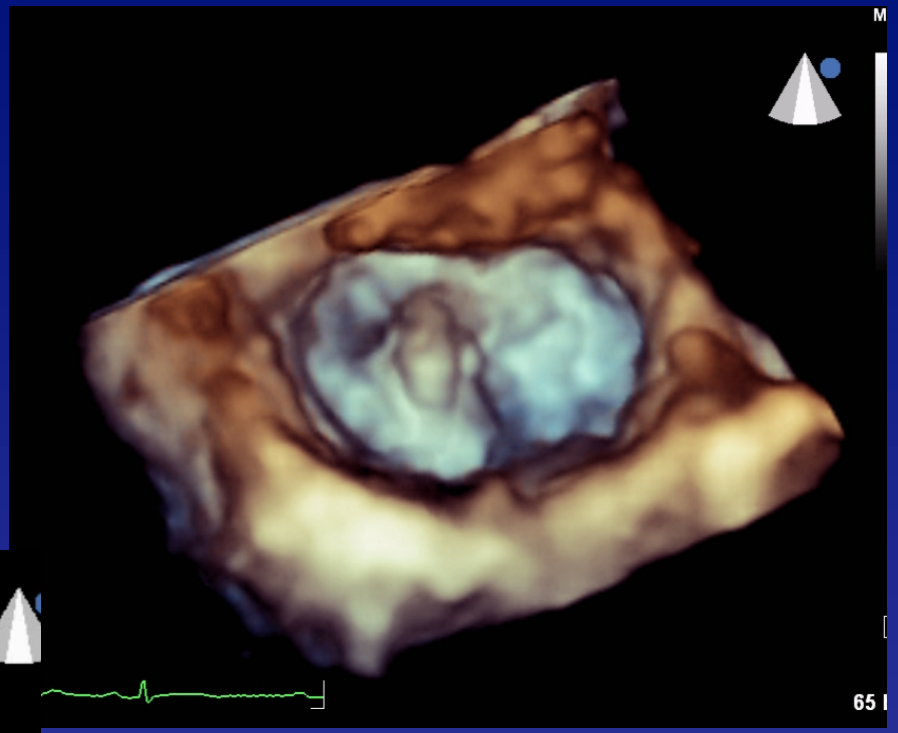
..3DTTE and 2DTEE had similar accuracies (90 % and 87%, respectively), while the accuracy of 2DTT (77.2 %) was significantly lower.

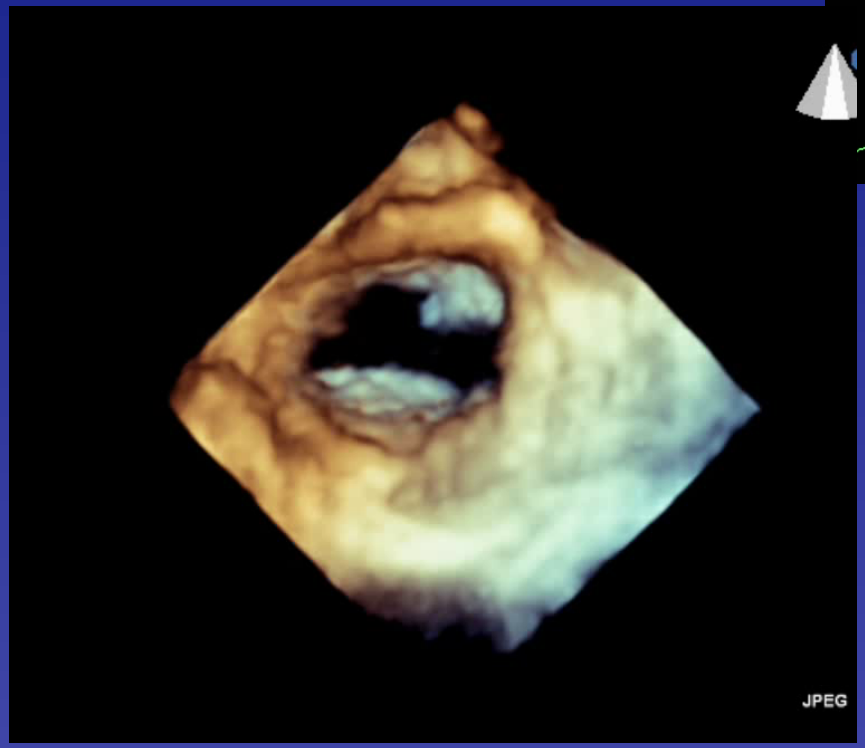


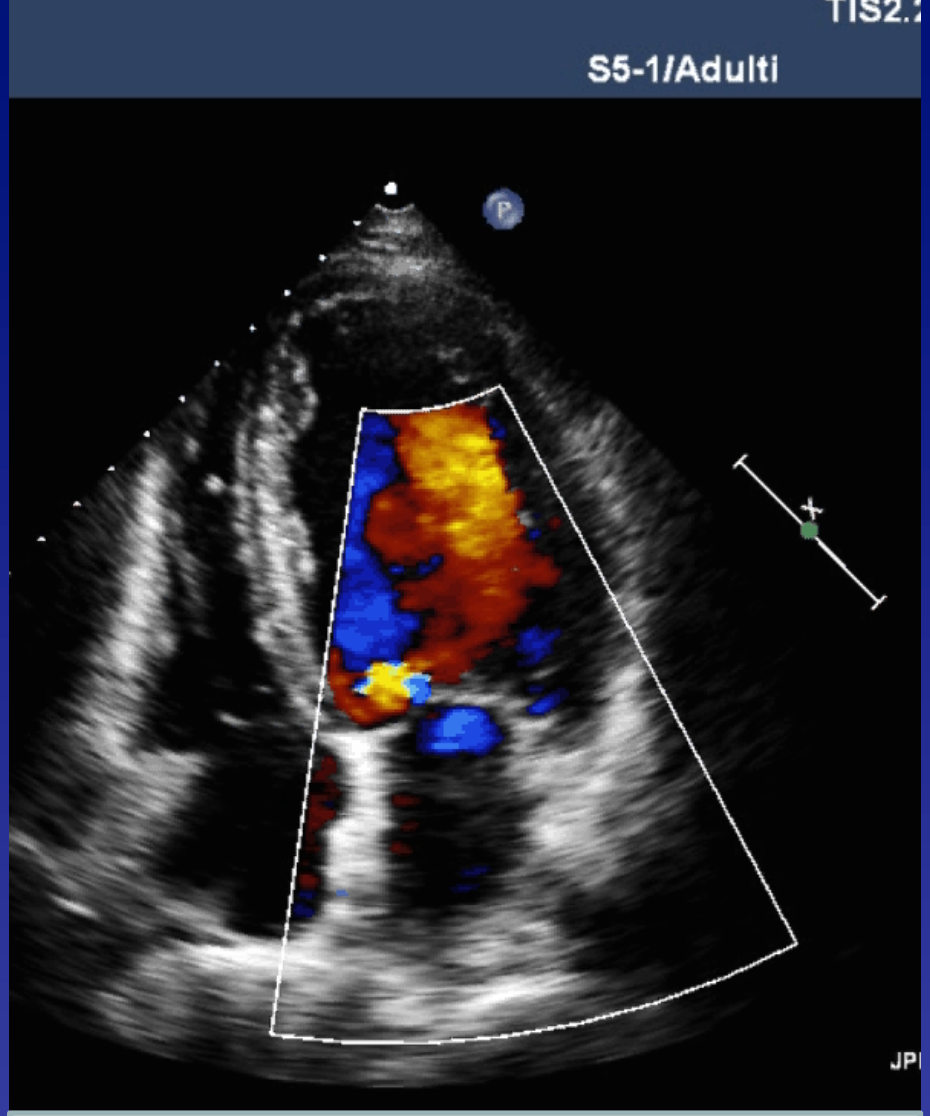
……since real time transthoracic 3D echo has an accuracy similar to that of 2D TEE new technique (which is also simple and rapid) may be integrated in the standard 2 D examination and should be regarded as an important examination in decision regarding MV repair

Pepi et al JACC 2006

Prolasso P2





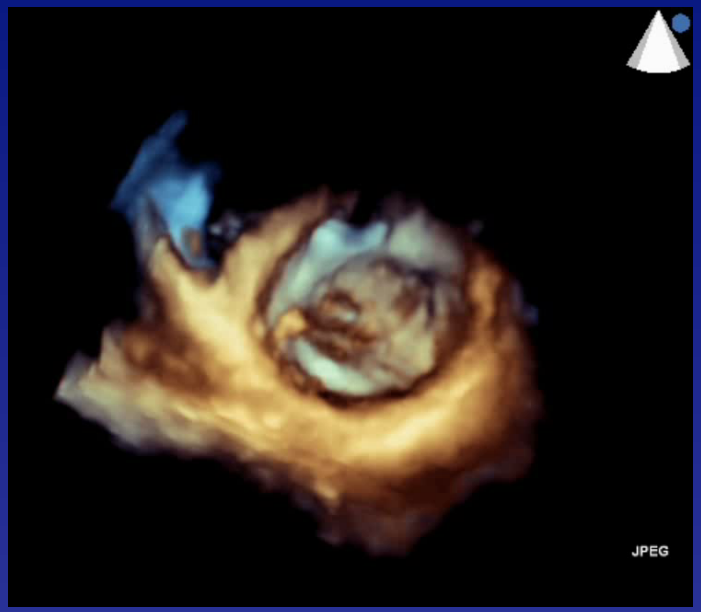


Severe MR

Zoom from the apical view: real time obtained in few seconds.
P1 prolapse; large scallop

A2-A3 prolapse

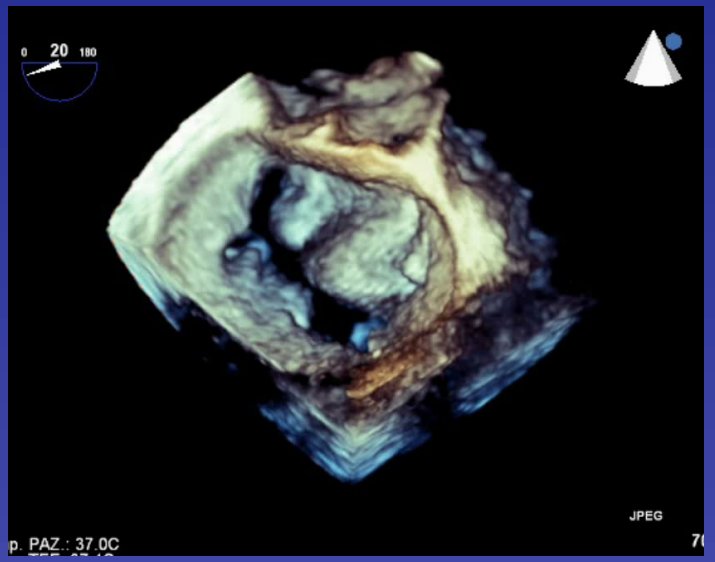
3DTTE

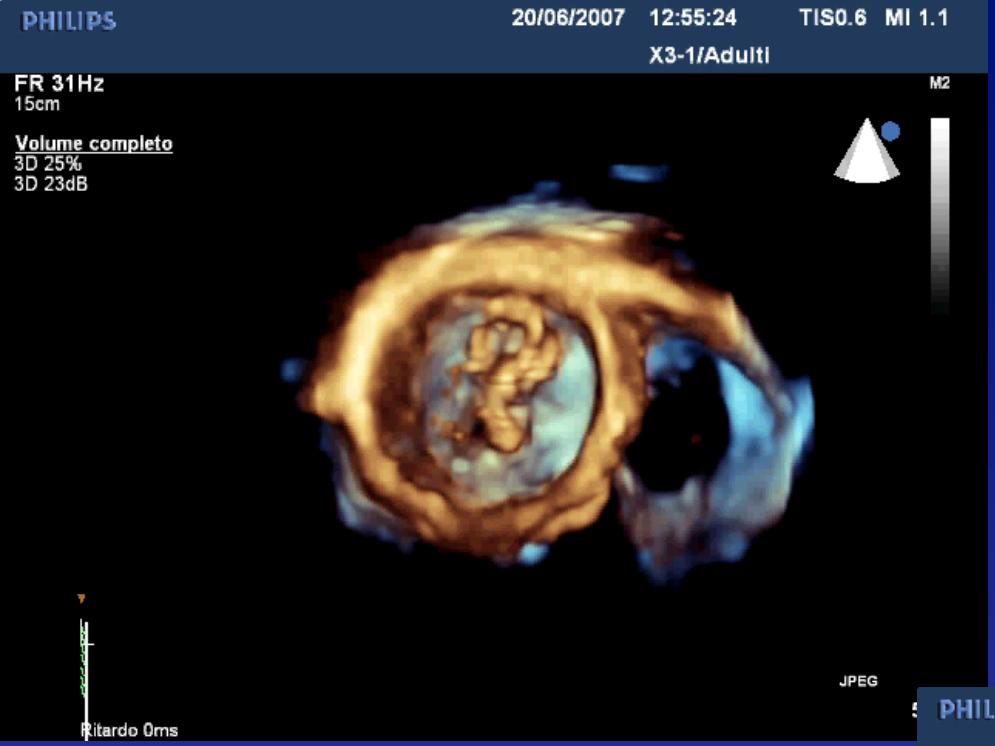


Visione dal ventricolo

Surgical view

3DTEE



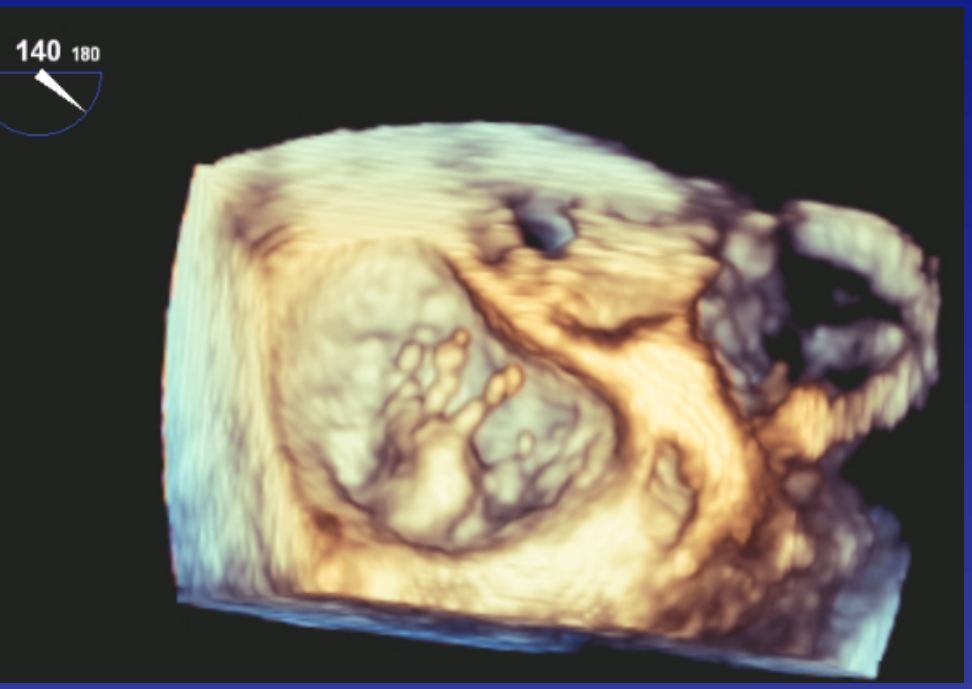


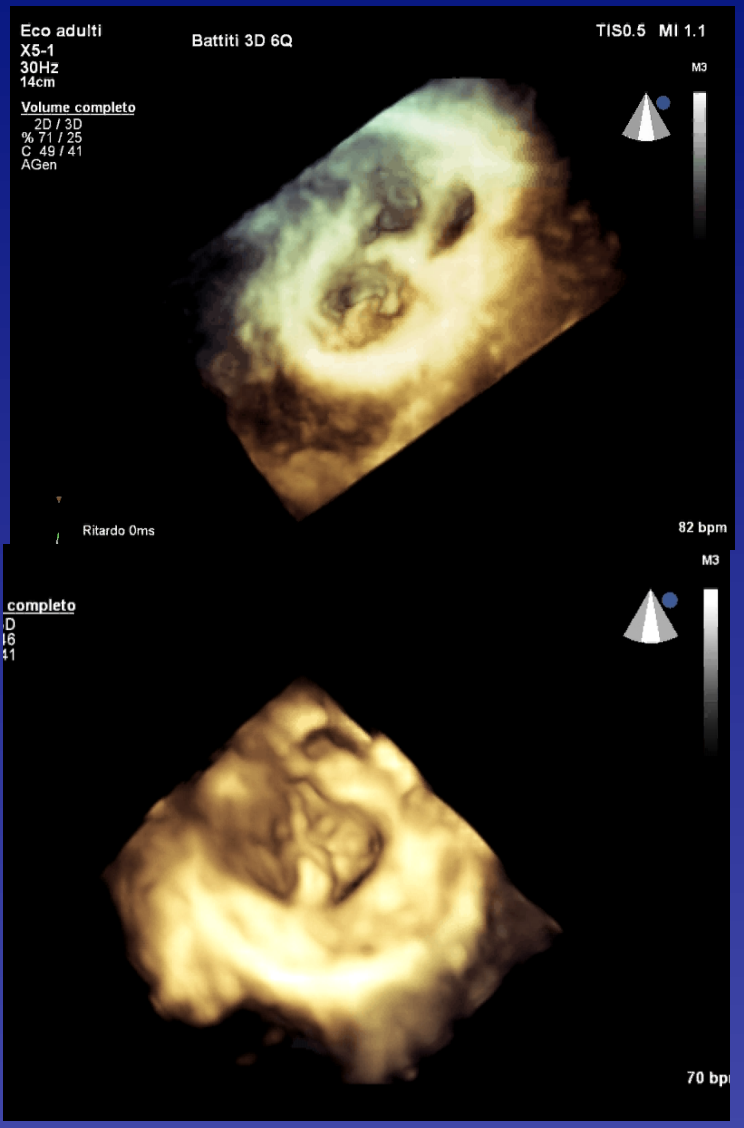
Ampio e complesso
Prolasso A2 A3 e commissura
Mediale e P1

Visione dal ventricolo

Surgical
view

NUOVA TECNOLOGIA 3DTTE 2014

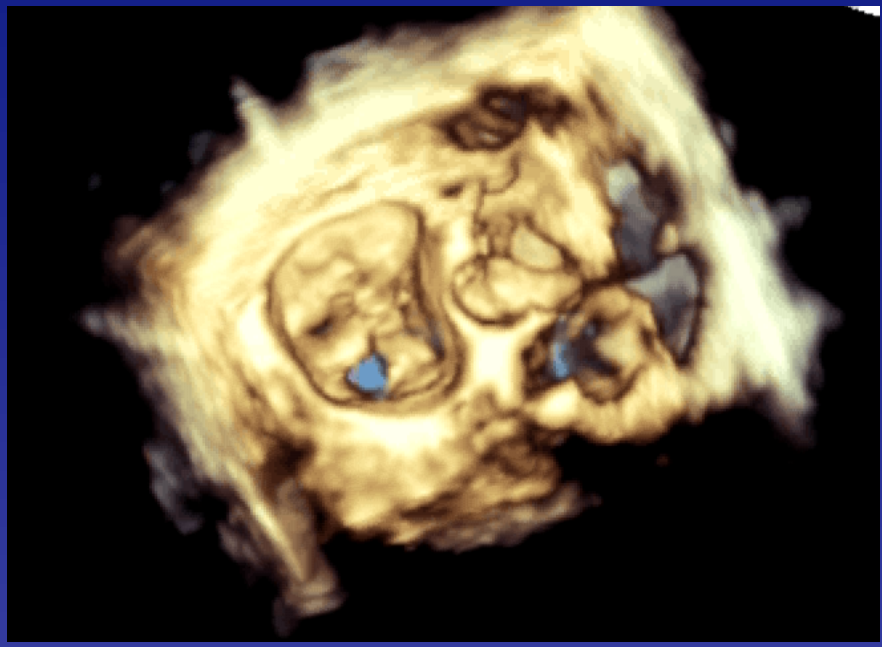




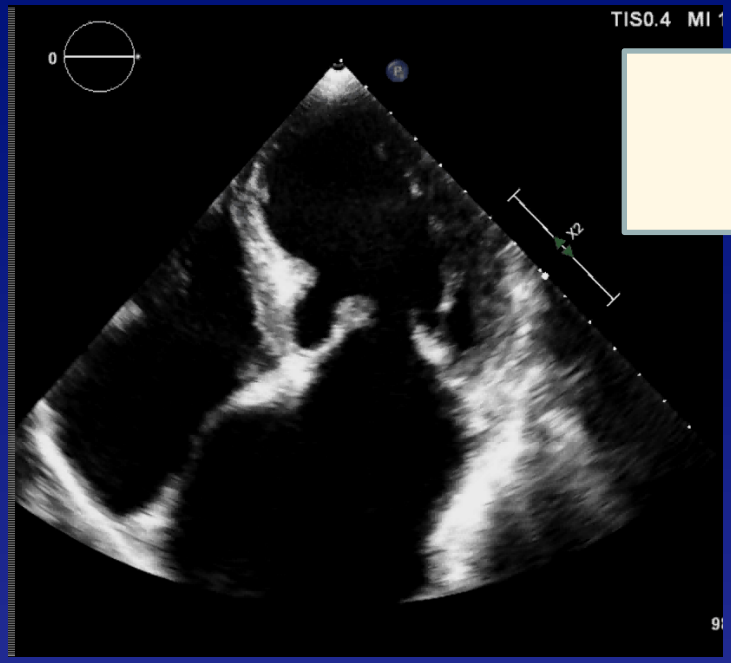
Flail P 2 Isolato

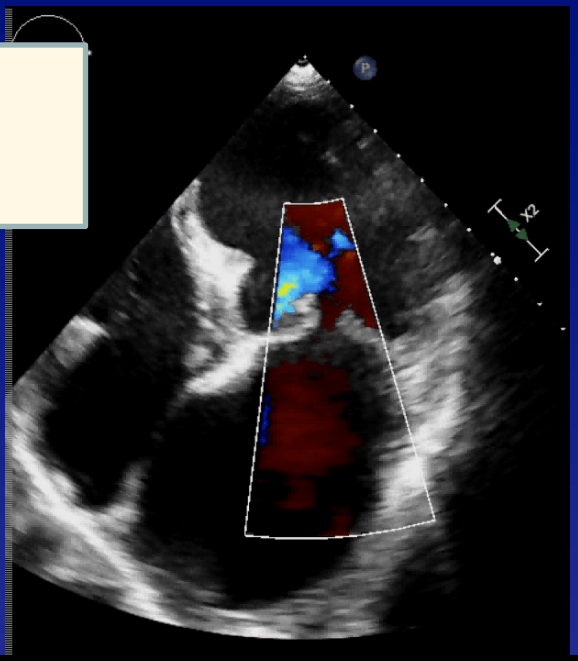
Transtoracico 3D
Real Time

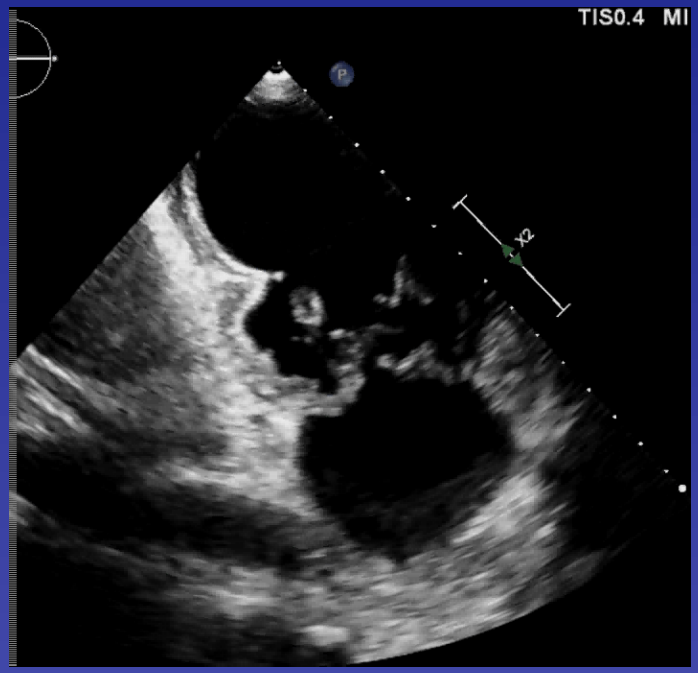
Transesofageo 3D
Full Volume

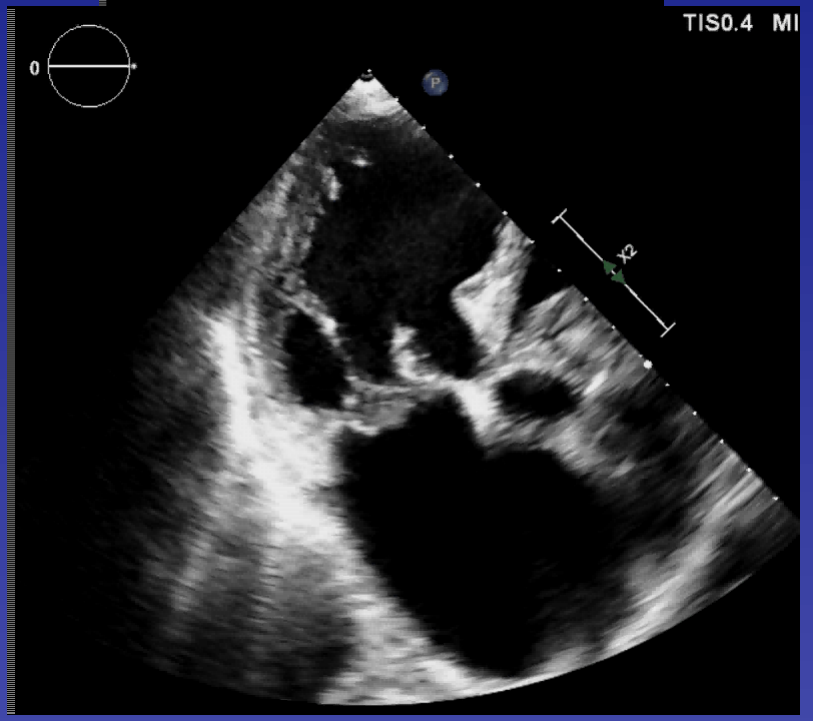


Caso 1

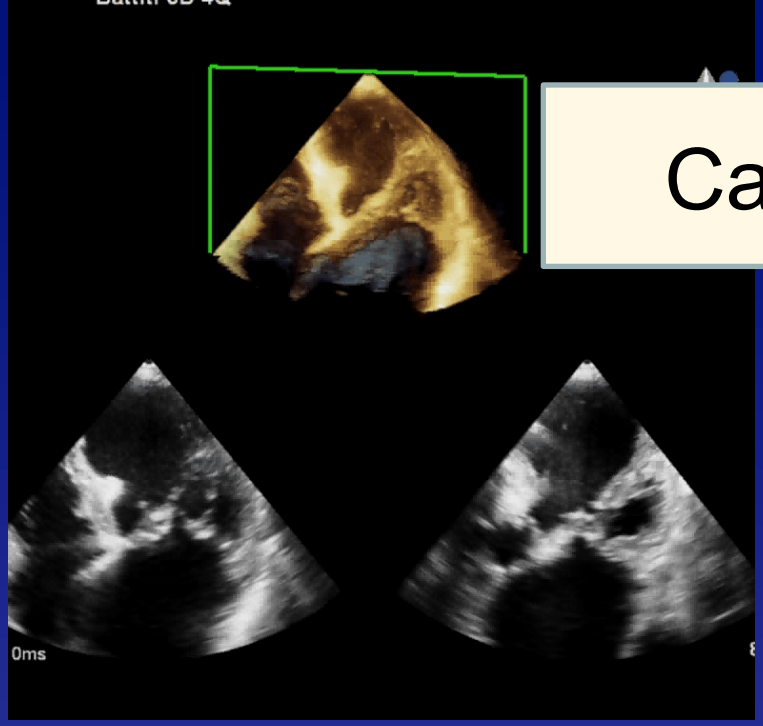


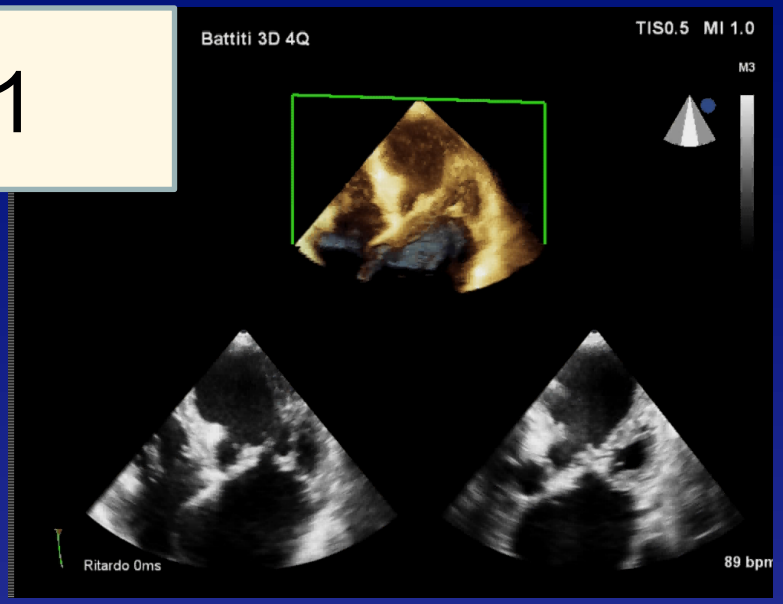


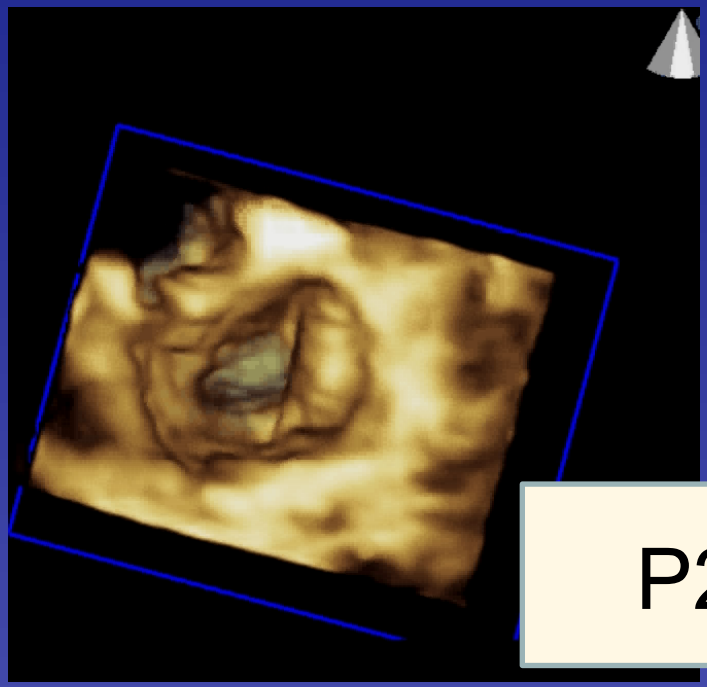


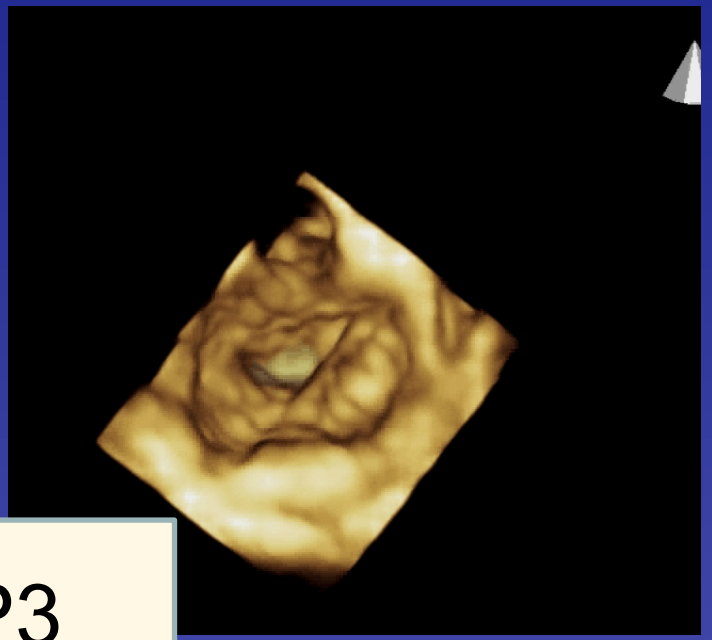


Caso 1



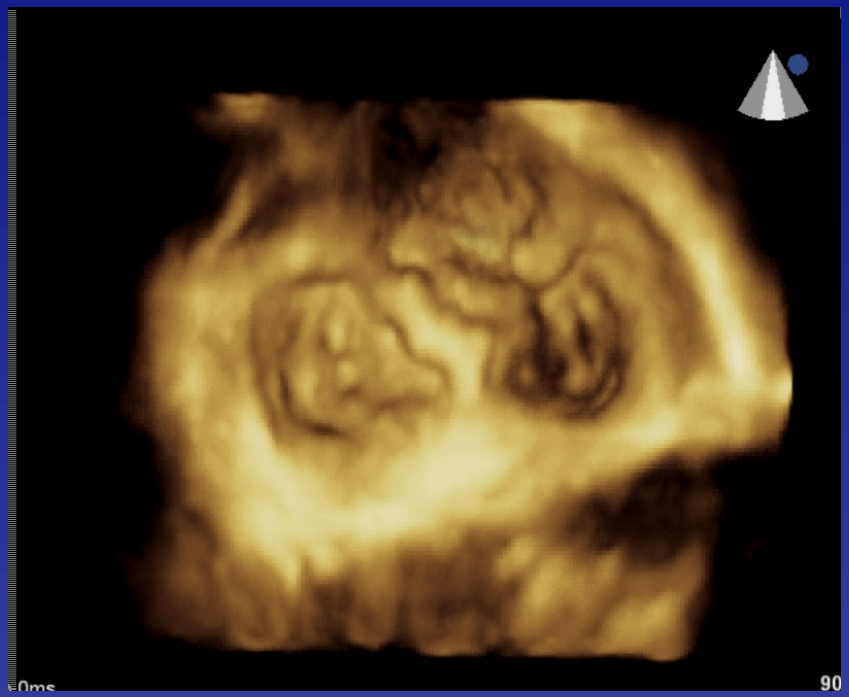


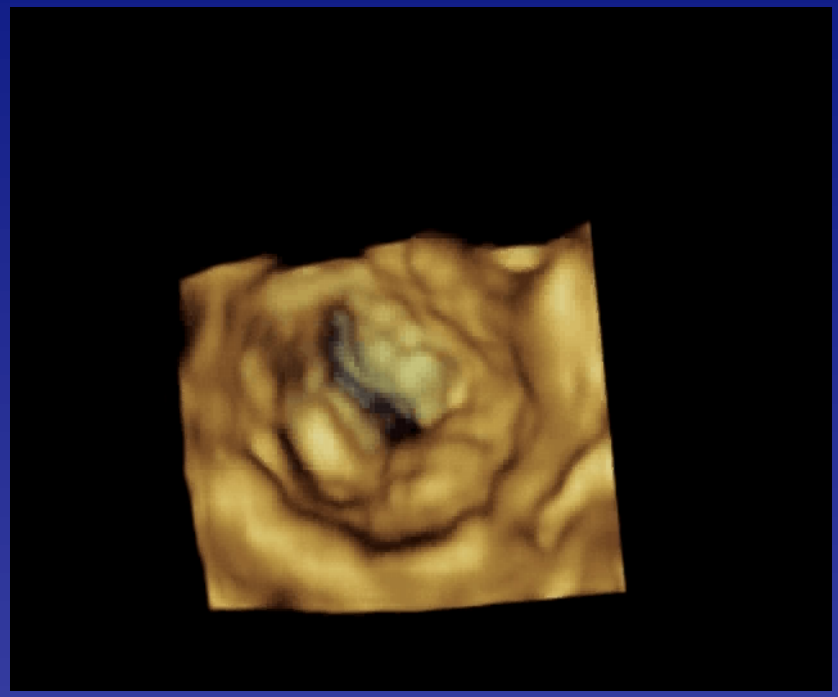




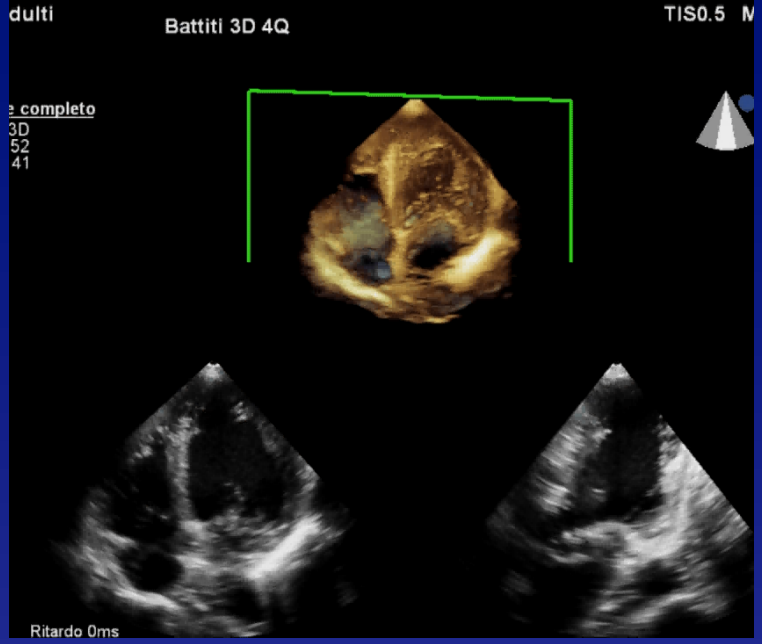
P2 – P3

Caso 1



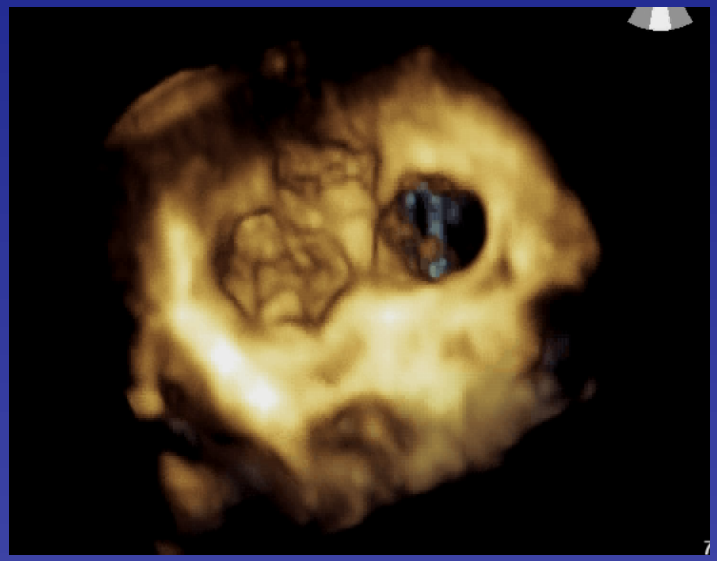


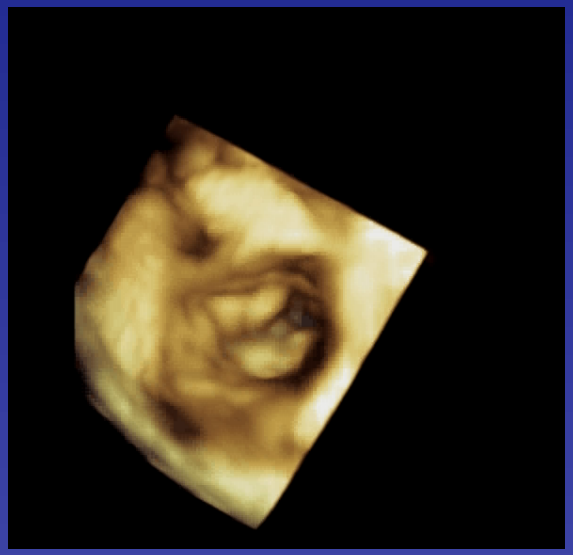
P2 – P3

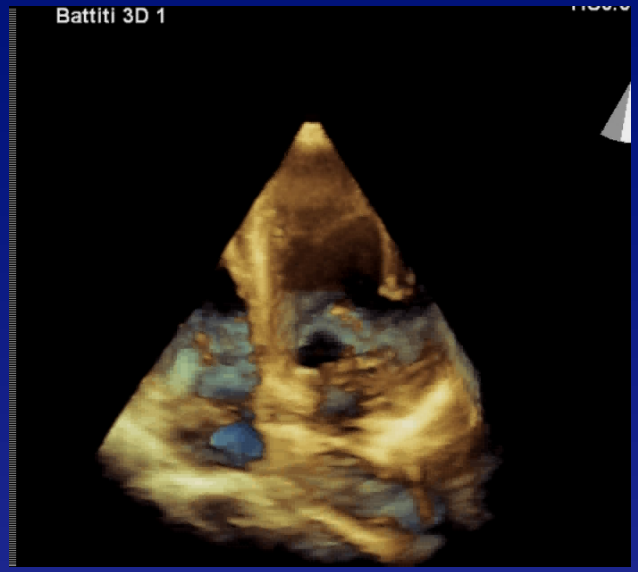


Caso 2

Flail large
P2

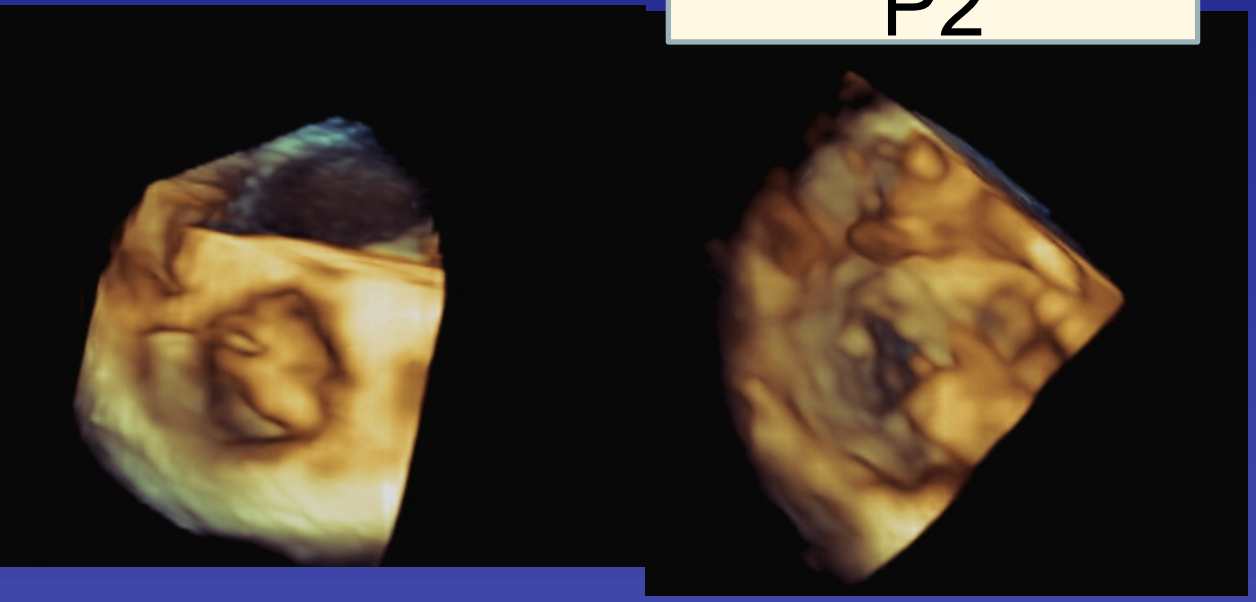


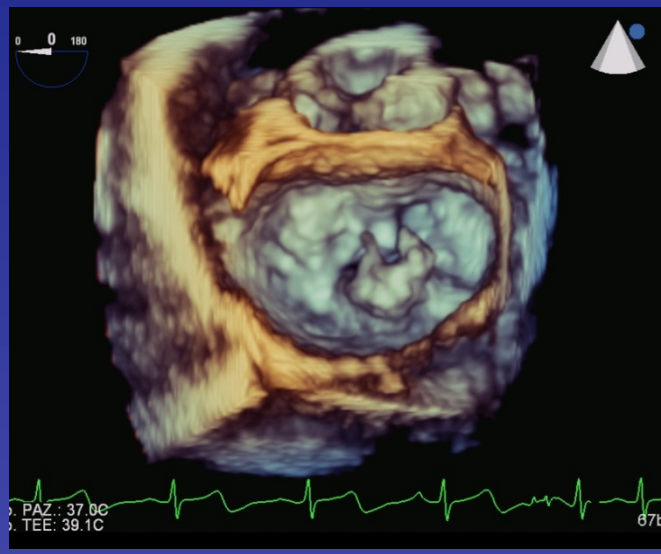




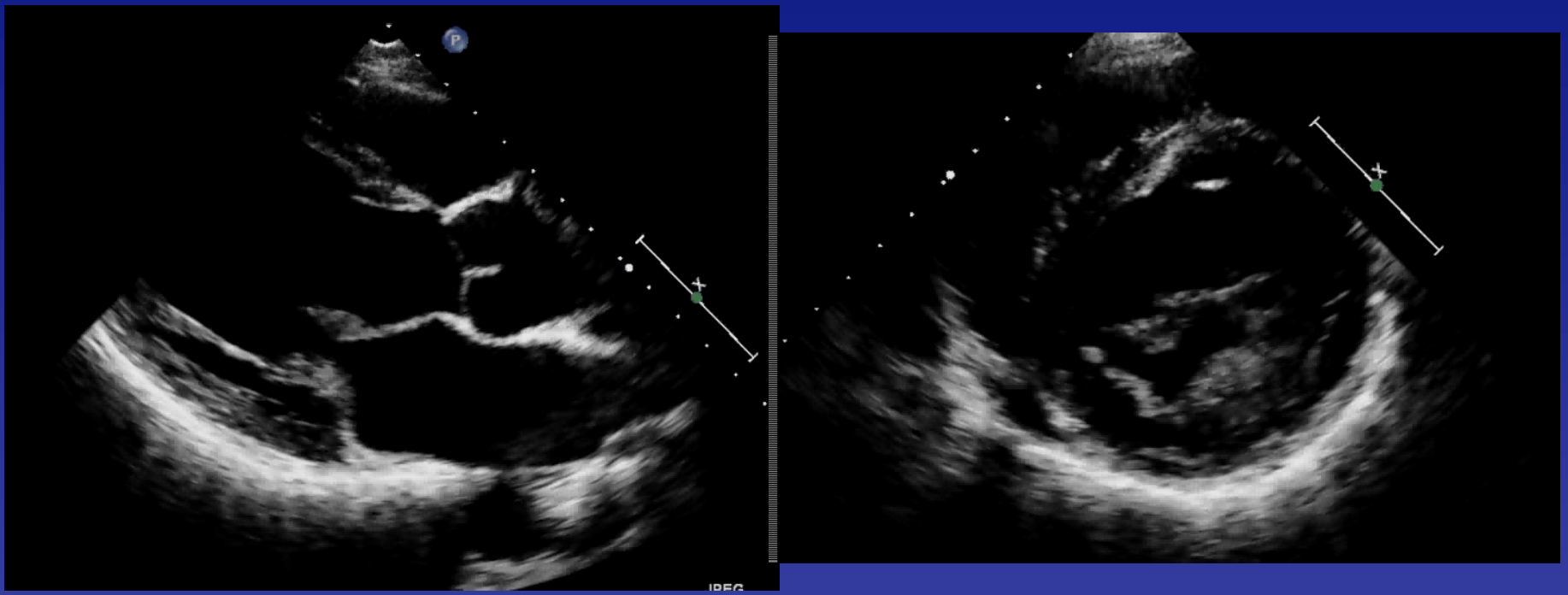
Caso 2

Flail large P2

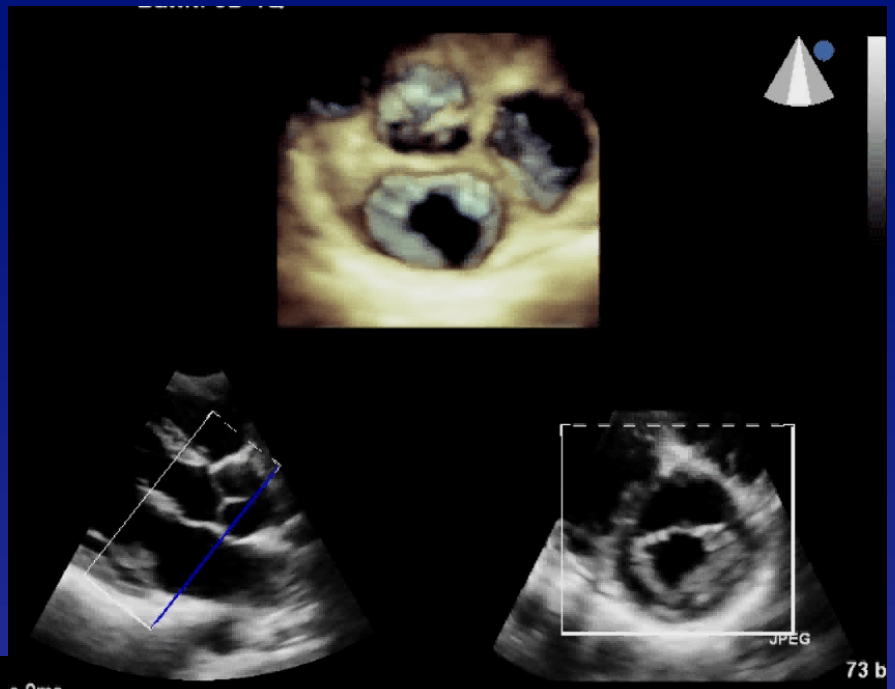


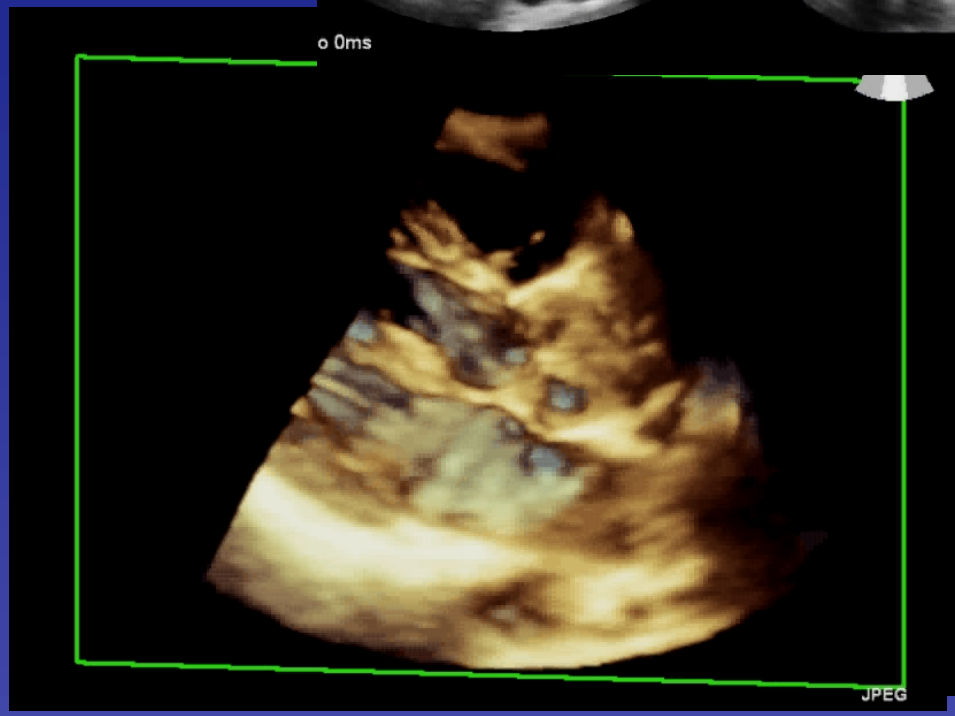


Caso 4



Barlow
P2- A2

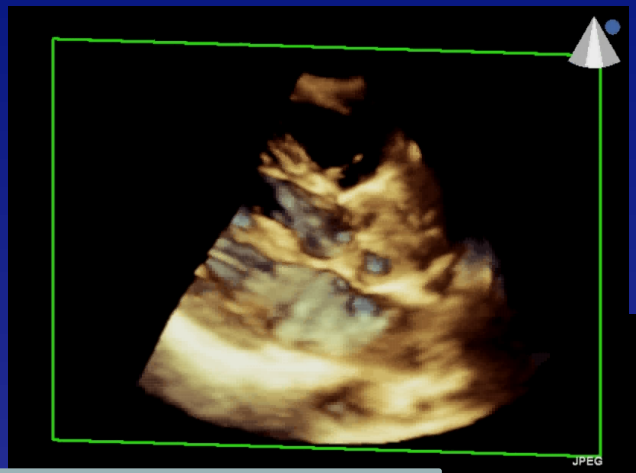




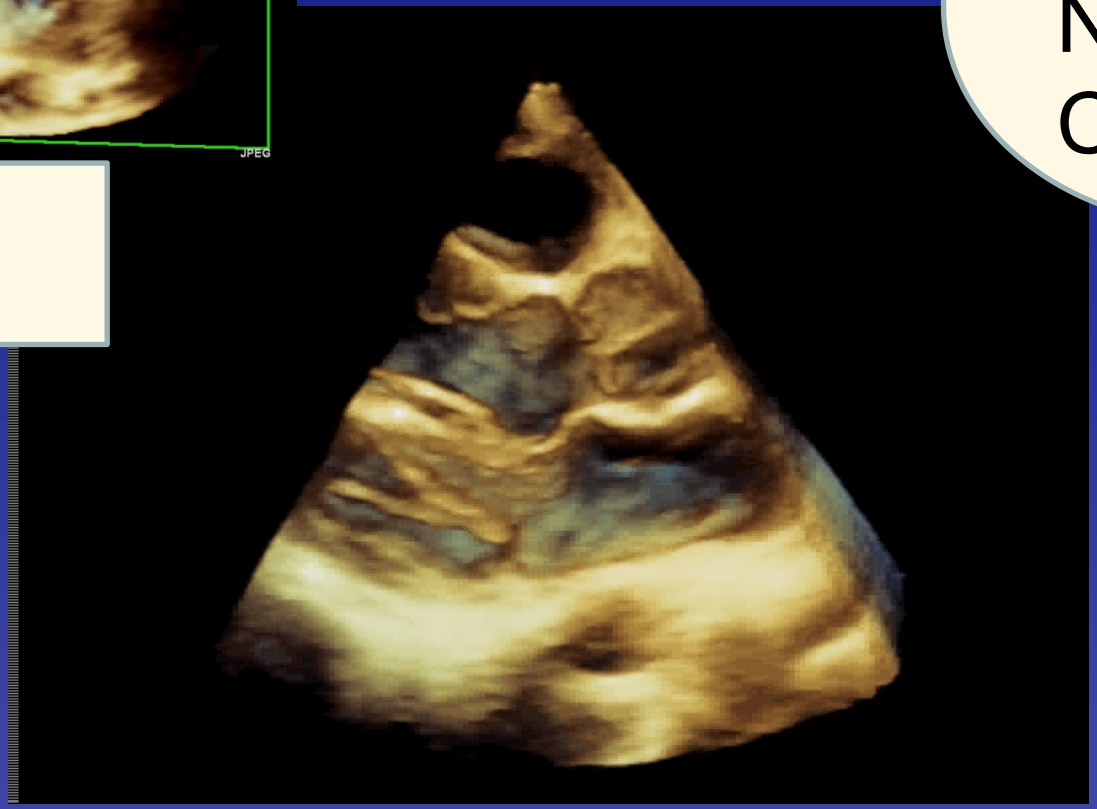
Caso 4

Barlow
P2- A2

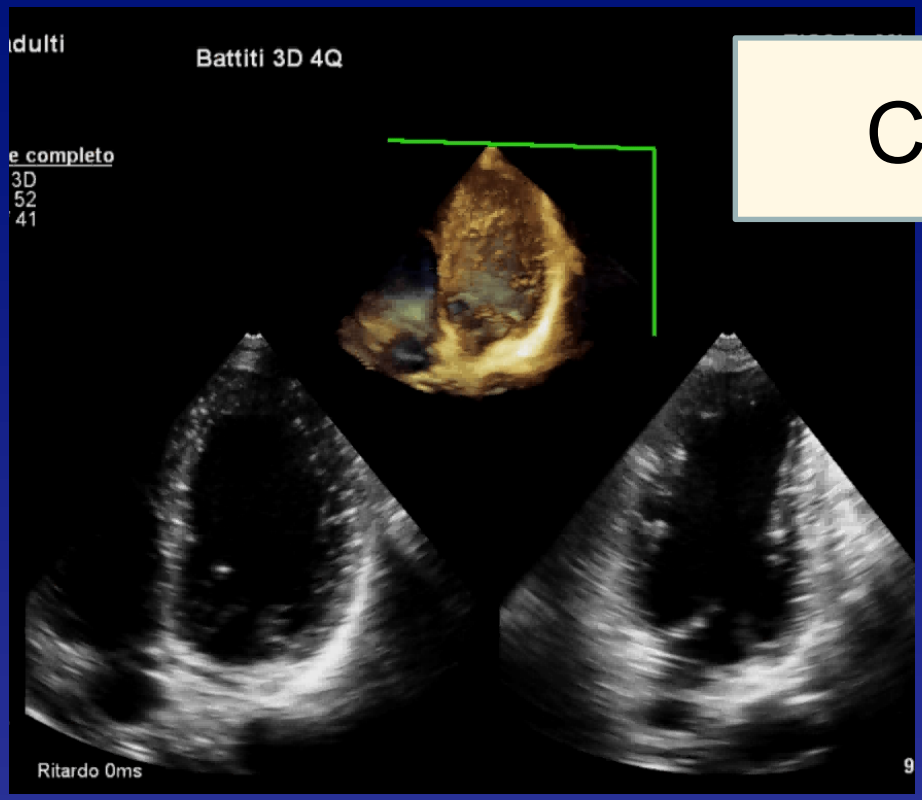
Caso 4



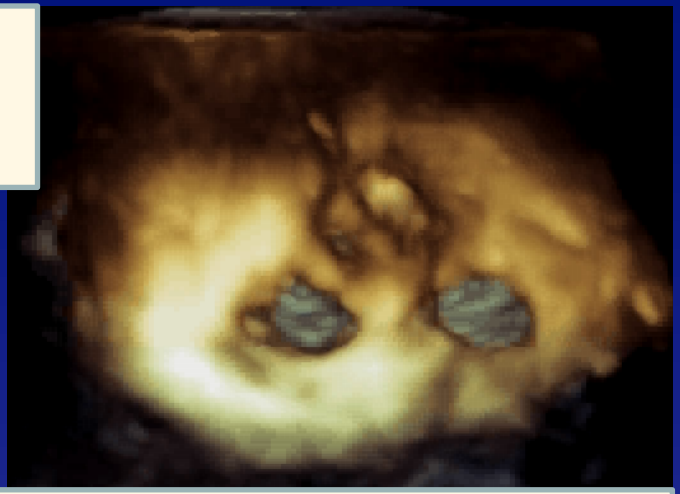
Barlow
P2- A2



Impianto
Neo
Corde

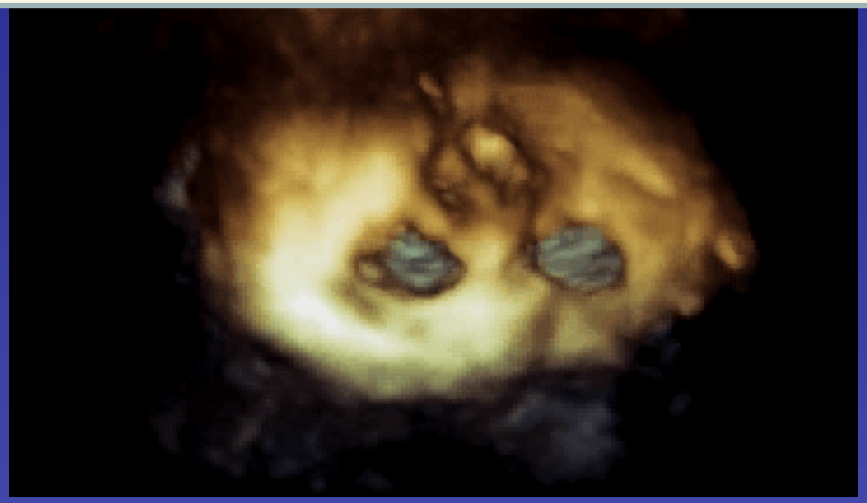


Caso 5

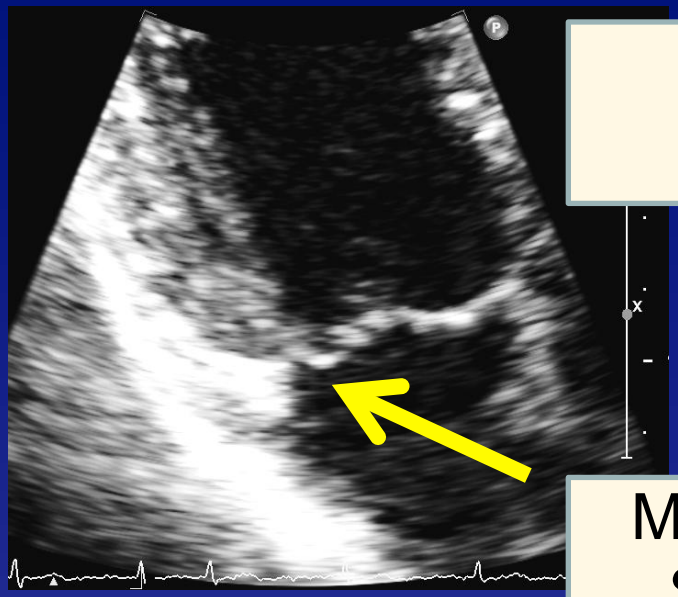


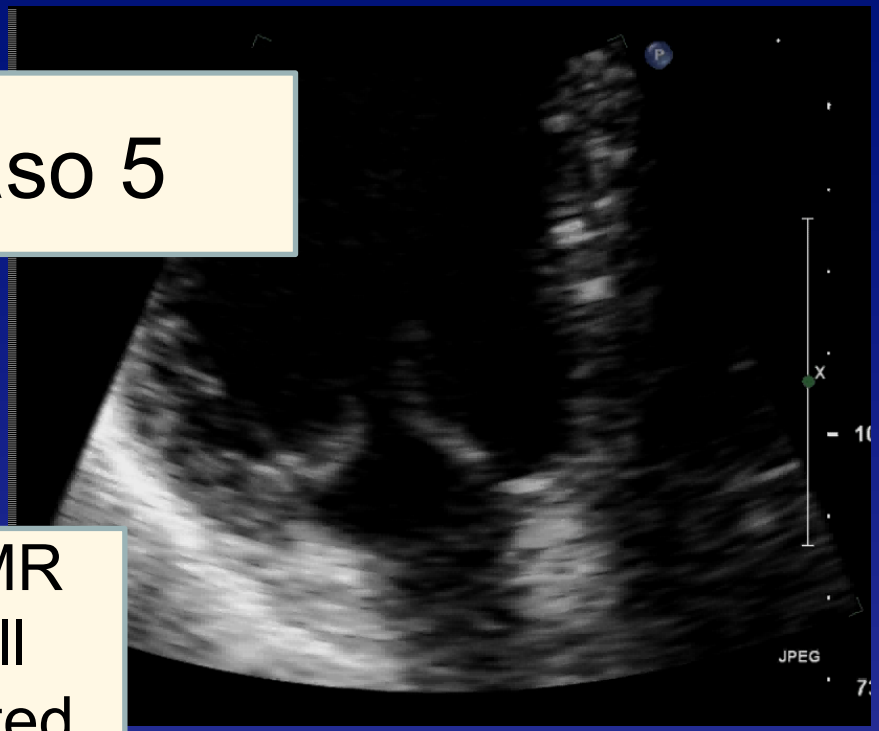
Report from another hospital:
Chordal rupture Flail P2

Mild MR
Small loculated P2 prolapse

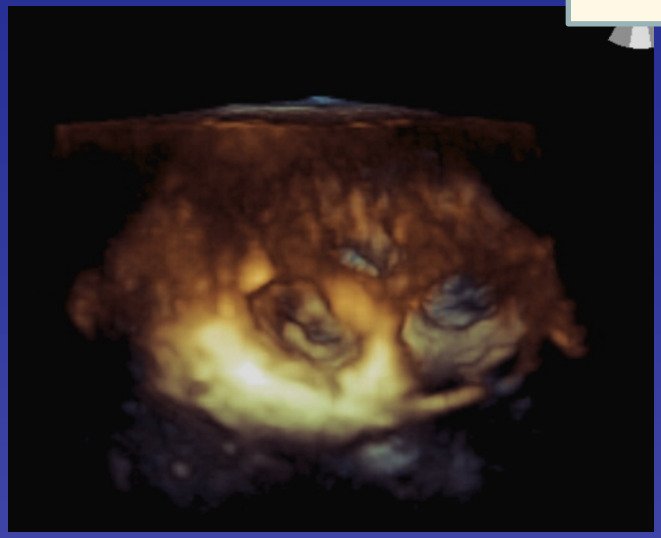


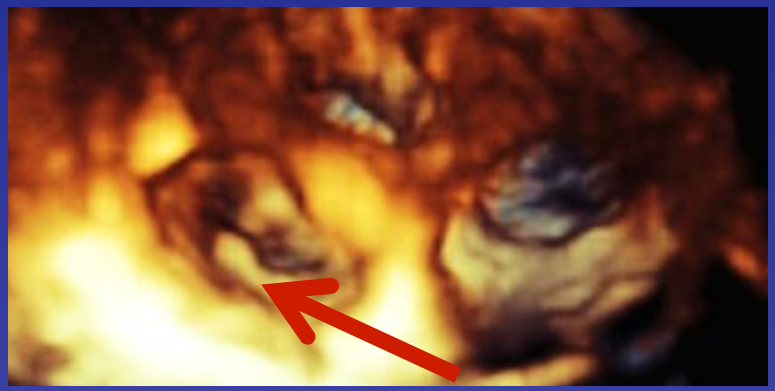
Caso 5



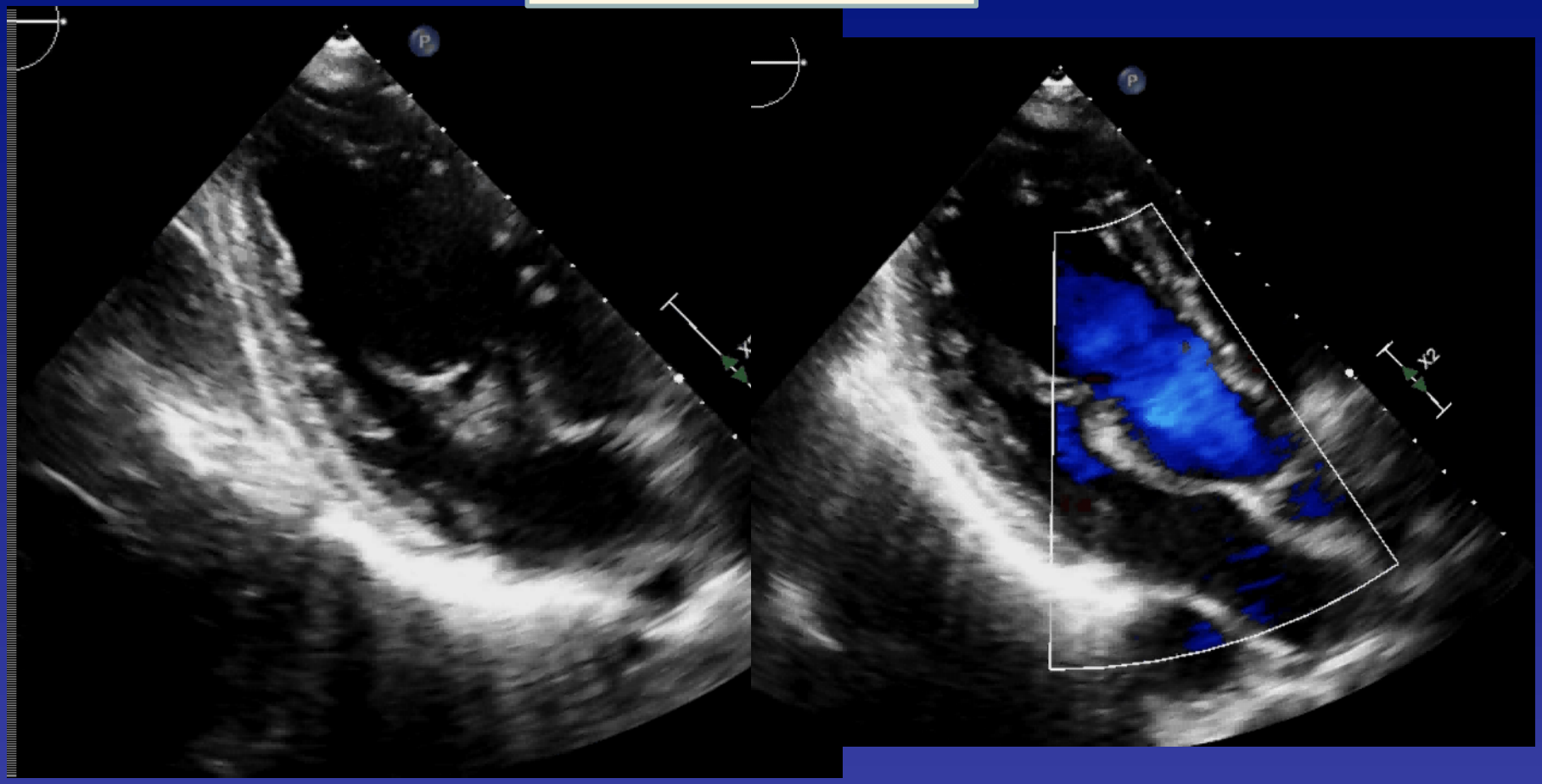


Mild MR
Small loculated P2

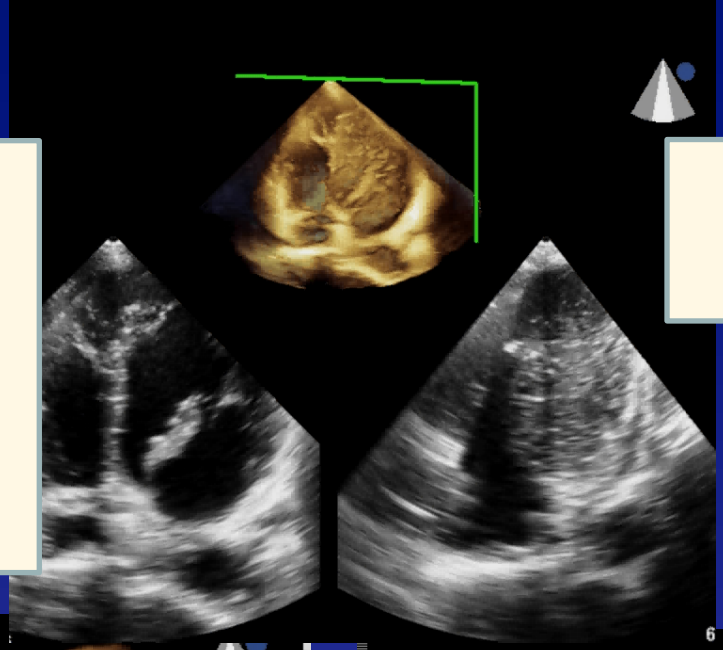




Caso 6

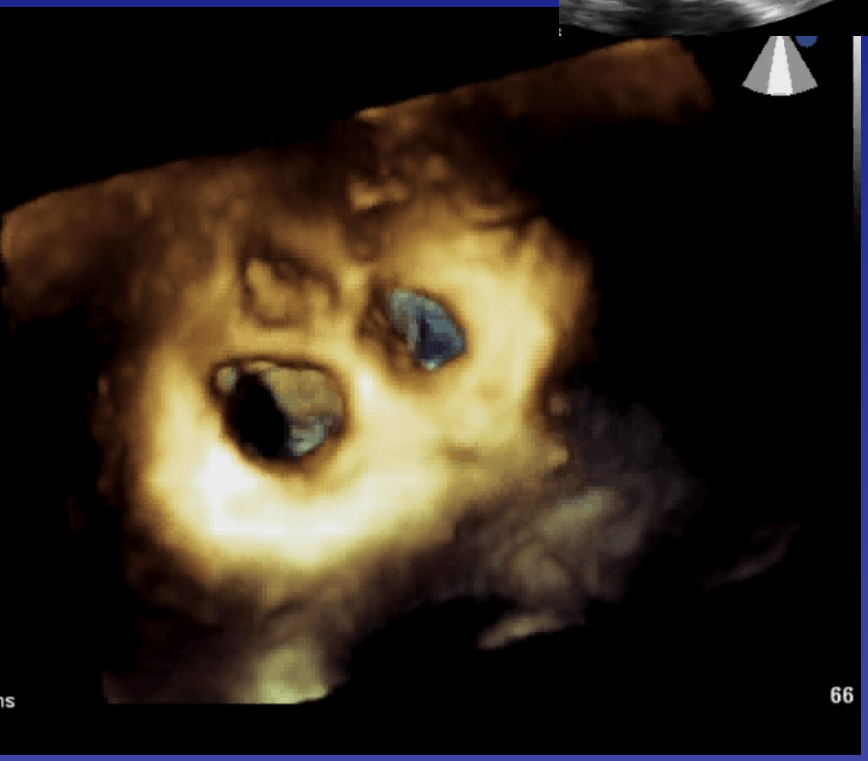


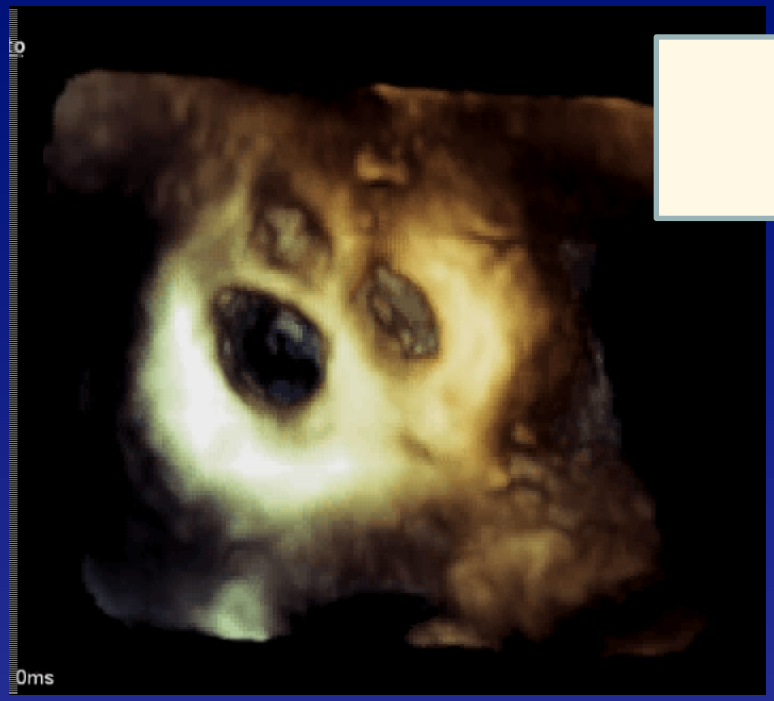
Barlow
Very small
Posterior
Leaflet



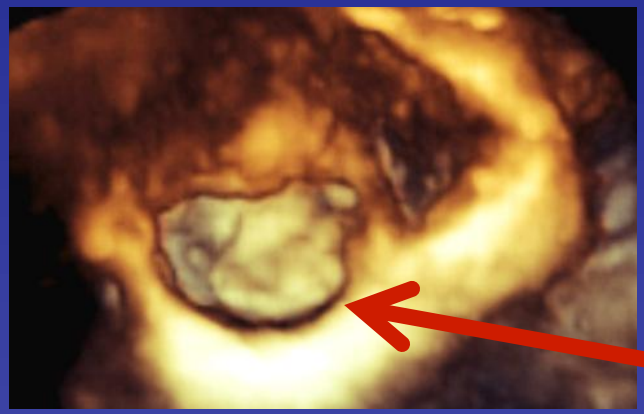
Caso 6

Barlow
Large A2-A3





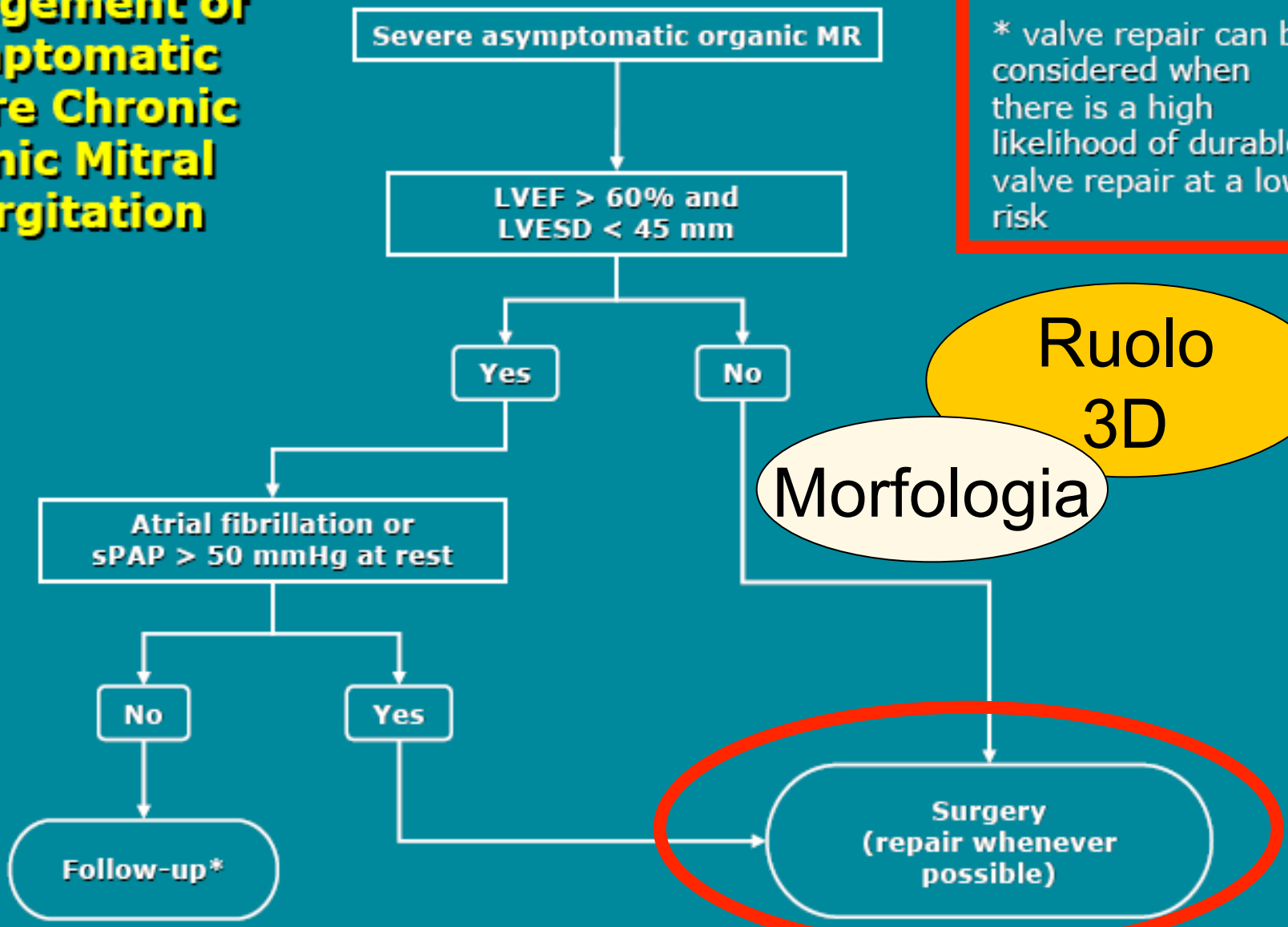
Caso 6



Barlow
Large A2-A3

Barlow
Very small
Posterior
Leaflet

Management of Asymptomatic Severe Chronic Organic Mitral Regurgitation



* valve repair can be considered when there is a high likelihood of durable valve repair at a low risk

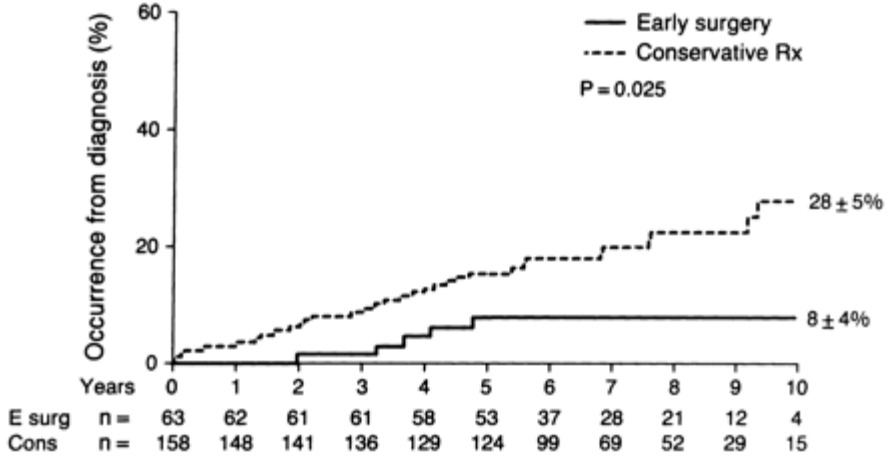
Ruolo 3D

Morfologia

Early Surgery in Patients With Mitral Regurgitation Due to Flail Leaflets

A Long-term Outcome Study

Lieng H. Ling, MB, BS, MRCP; Maurice Enriquez-Sarano, MD; James B. Seward, MD; Thomas A. Orszulak, MD; Hartzell V. Schaff, MD; Kent R. Bailey, PhD; A. Jamil Tajik, MD; ; Robert L. Frye, MD
Mayo Clinic and Mayo Foundation, Rochester, Minn.

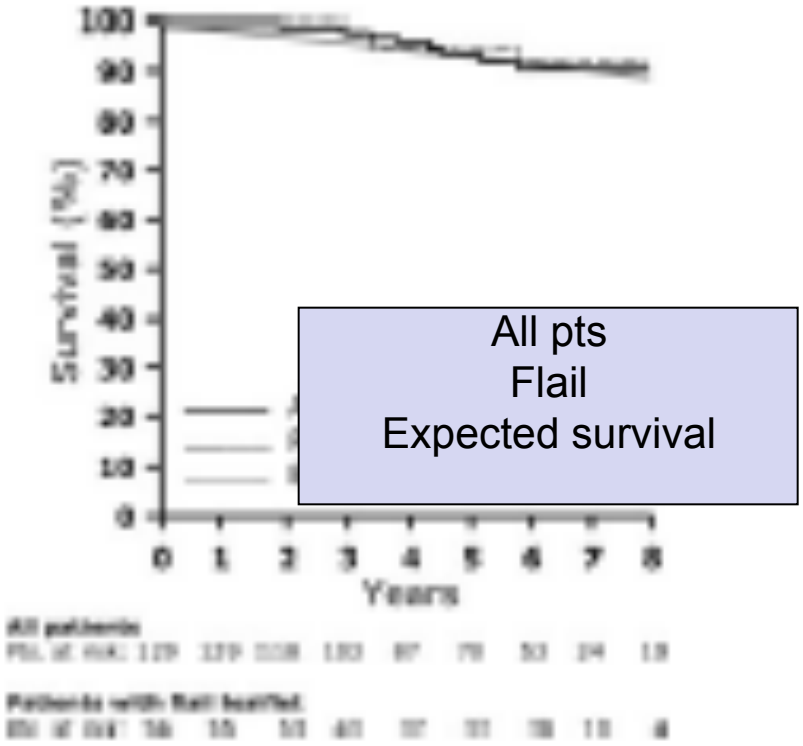


Pts with flail MV
Early surgery vs Conservative management improved long-term survival

Circulation 1997

Outcome of Watchful Waiting in Asymptomatic Severe Mitral Regurgitation

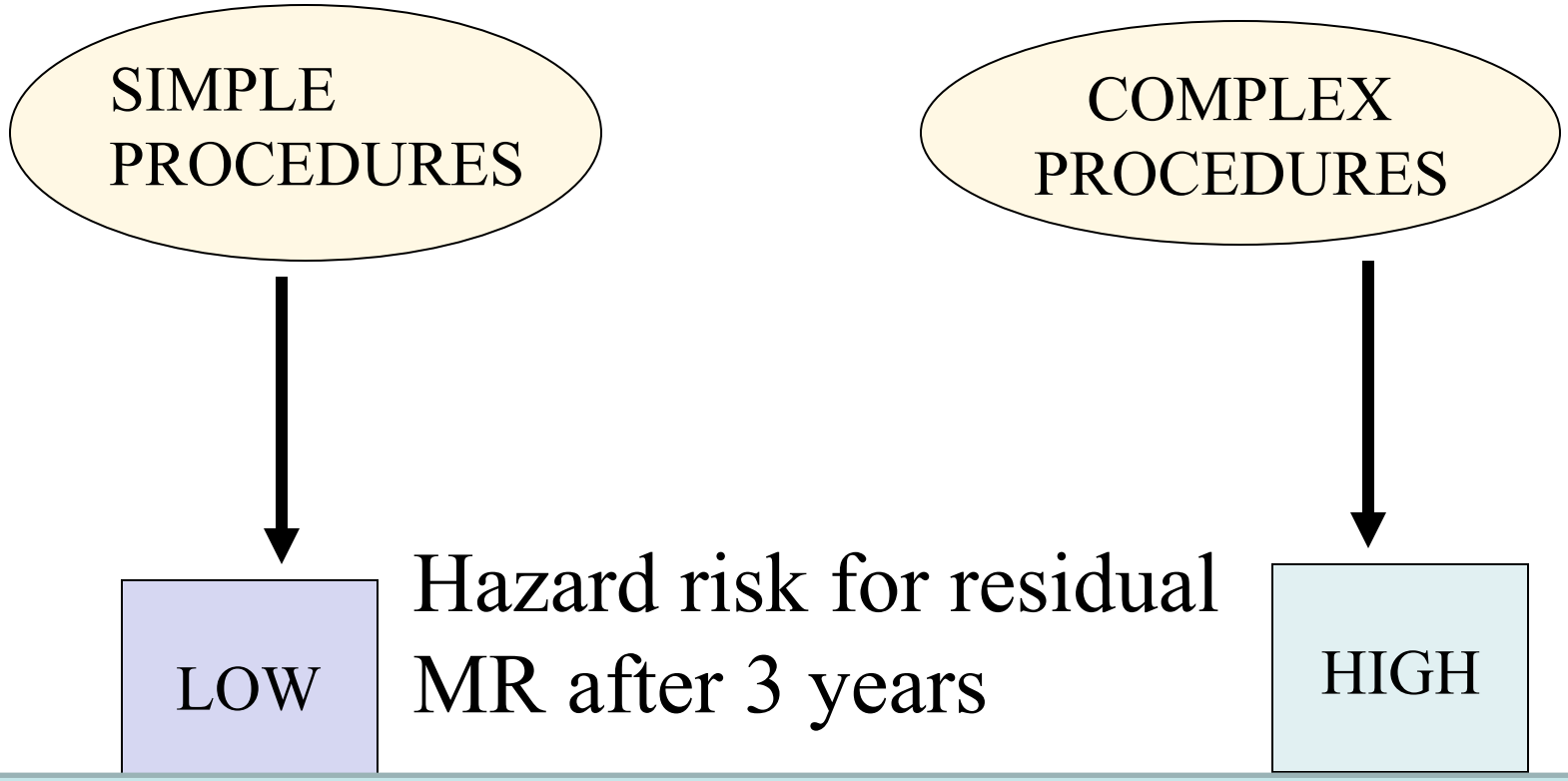
Raphael Rosenhek, MD; Florian Rader, MD; Ursula Klaar, MD; Harald Gabriel, MD; Marcel Krejc, PhD; Daniel Kalbeck, PhD; Michael Schemper, PhD; Gerald Maurer, MD; Helmut Baumgartner, MD



Asymptomatic pts with severe degenerative MR can be safely followed-up until their symptoms occur or currently recommended cutoff values for LV size, LV function or pulmonary hypertension are reached.

Circulation 2006

LONG–TERM RESULTS OF VALVE REPAIR WITH SIMPLE OR COMPLEX TECHNIQUES IN NONRHEUMATIC MV REGURGITATION



2008-2010: Nostra impostazione scientifica: è possibile predire tipo intervento con ECO 3D ?

ASSESSMENT OF REGURGITATION AFTER MITRAL VALVE REPAIR: follow-up

- 264 pts TT long term study.
- Mean freedoms from regurgitation:
- At 1 year : 91.5 %
- At 5 years: 47.5% (6.2% moderate)
- **Factors influencing MR**: poor LV function, age, chordal procedures.

Lim et Al J Thoracic Cardiovasc Surg 2002

SURVIVAL ADVANTAGE AND IMPROVED DURABILITY OF MITRAL REPAIR FOR LEAFLETS PROLAPSE SUBSETS IN THE CURRENT ERA

- 1441 ISOLATED MV PROLAPSE (MAYO)
- MV REPAIR 1173
- Factors influencing SURVIVAL younger age, better NYHA, no CAD.
- Adjusted for age : smaller LV eSV, EF
- Reoperation similar repair vs replacement

Reoperation 97 pts – 75 repairs (6%) mean 4.8 years
Factors predicting reoperation:
Younger age – anterior leaflet prolapse – chordal shortening
- No leaflet resection – no anuloplasty – greater than mild residual regurgitation, CAD.

Suri Ann Thorac Surg 2006

Prevalence of Calcification of the Mitral Valve Annulus in Patients Undergoing Surgical Repair of Mitral Valve Prolapse

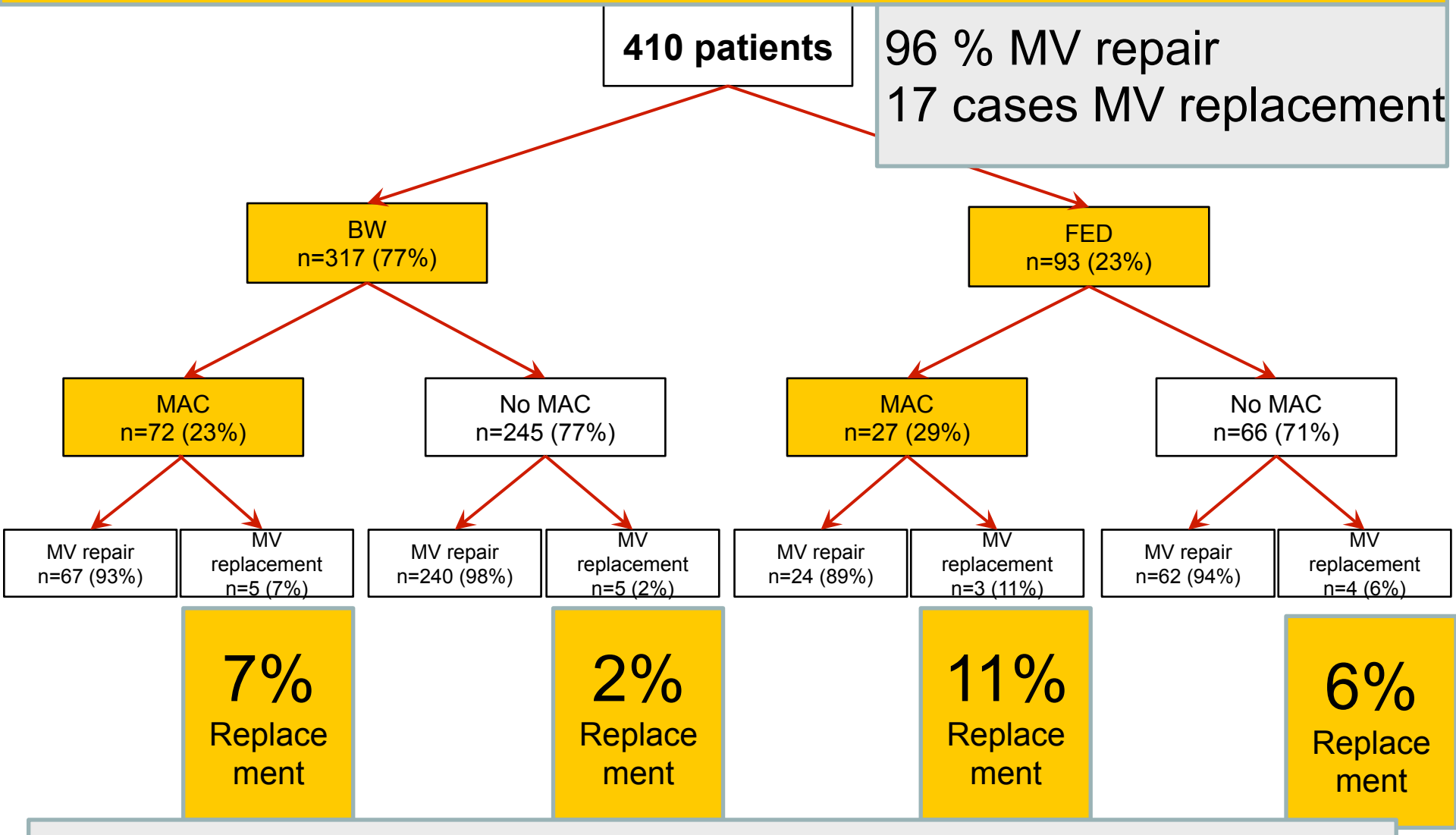
Laura Fusini, MS[a,*], Sarah Ghulam Ali, MD[a], Gloria Tamborini, MD[a], Manuela Muratori, MD[a], Paola Gripari, MD[a], Francesco Maffessanti, PhD[a], Fabrizio Celeste, MD[a], Marco Guglielmo, MD[a], Claudia Cefalù, MD[a], Francesco Alamanni, MD[a,b], Marco Zanobini, MD[a], and Mauro Pepi, MD[a]

MAC is a common finding in patients undergoing MV repair, and several clinical characteristics correlate with MAC either in FED or BD.

Despite very high percentage of repairability, MAC influences surgical outcomes and very detailed echo evaluation is advocated.

Am J Cardiol 2014

The presence of MAC Influences surgical outcomes



Very high percentage of MV repair

European Journal of Echocardiography Advance Access published May 20, 2010

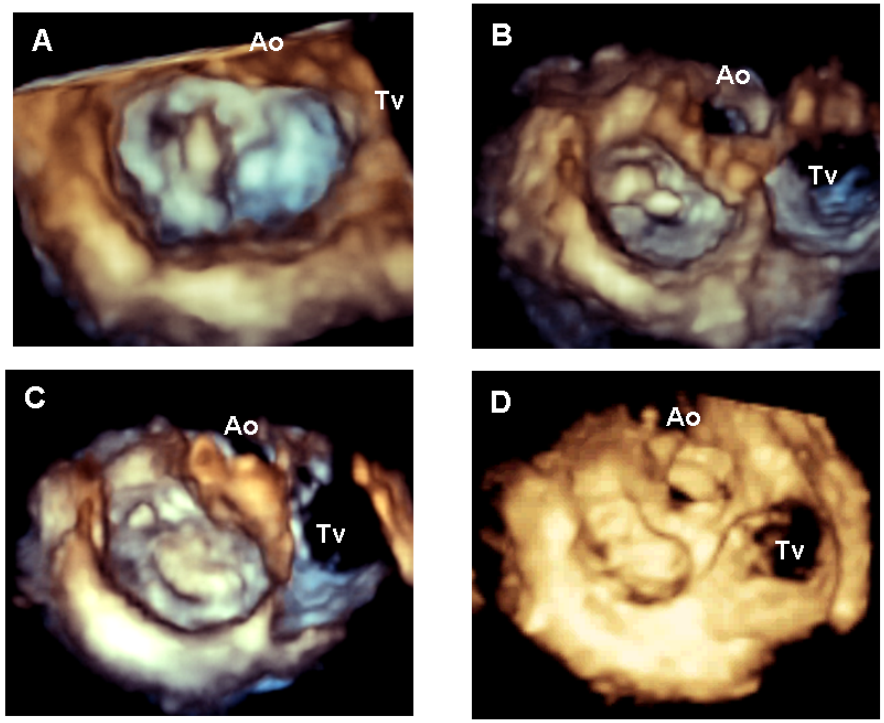
European Journal of Echocardiography
doi:10.1093/ejechocard/jeq066

Pre-operative transthoracic real-time three-dimensional echocardiography in patients undergoing mitral valve repair: accuracy in cases with simple vs. complex prolapse lesions

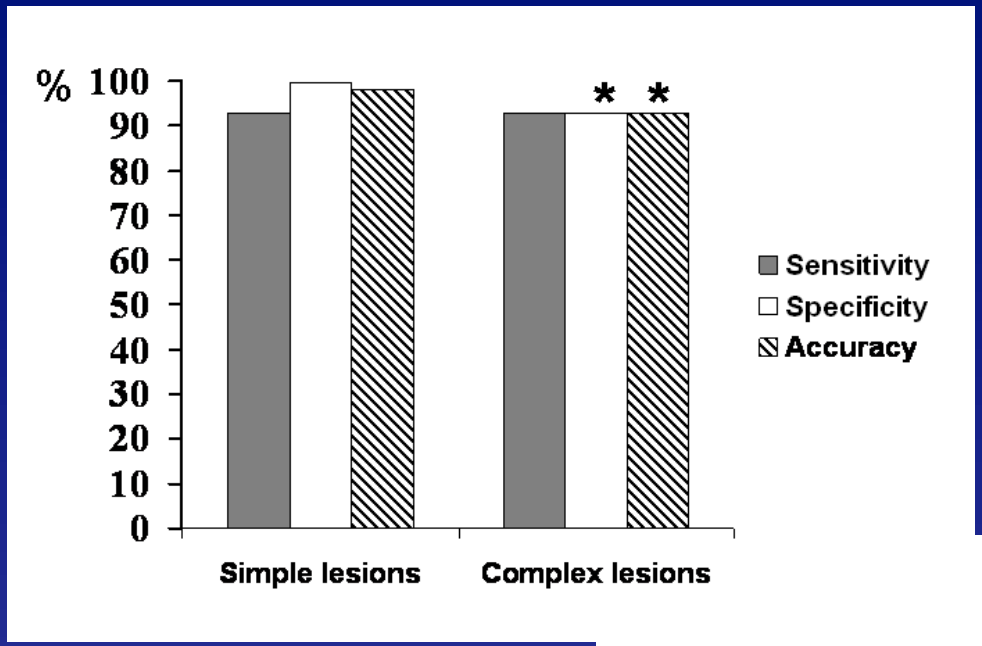
Gloria Tamborini*, Manuela Muratori, Anna Maltagliati, Claudia Agnese Galli, Moreno Naliato, Marco Zanobini, Francesco Alamanni, Luca Salvi, Erminio Sisillo, Cesare Fiorentini, and Mauro Pepi

Centro Cardiologico Monzino, IRCCS, Department of Cardiovascular Sciences, University of Milan, Via Parea 4, 20138 Milan, Italy

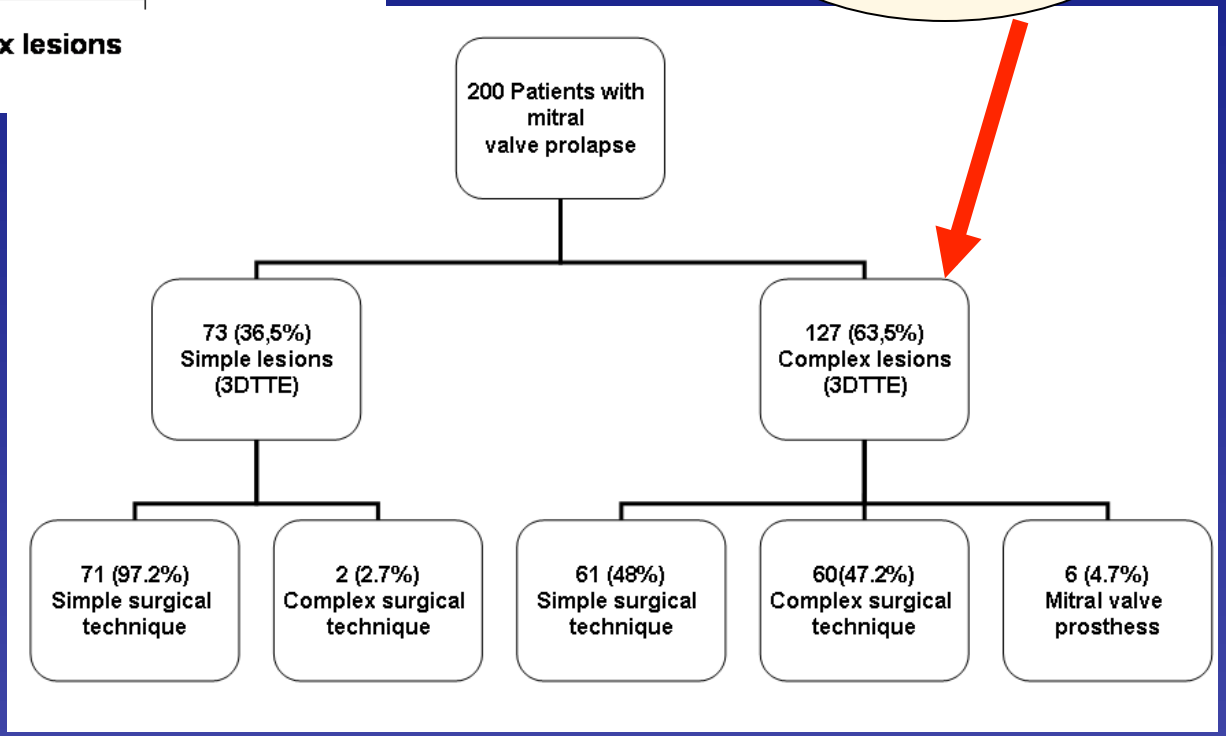
Received 5 February 2010; accepted after revision 25 April 2010



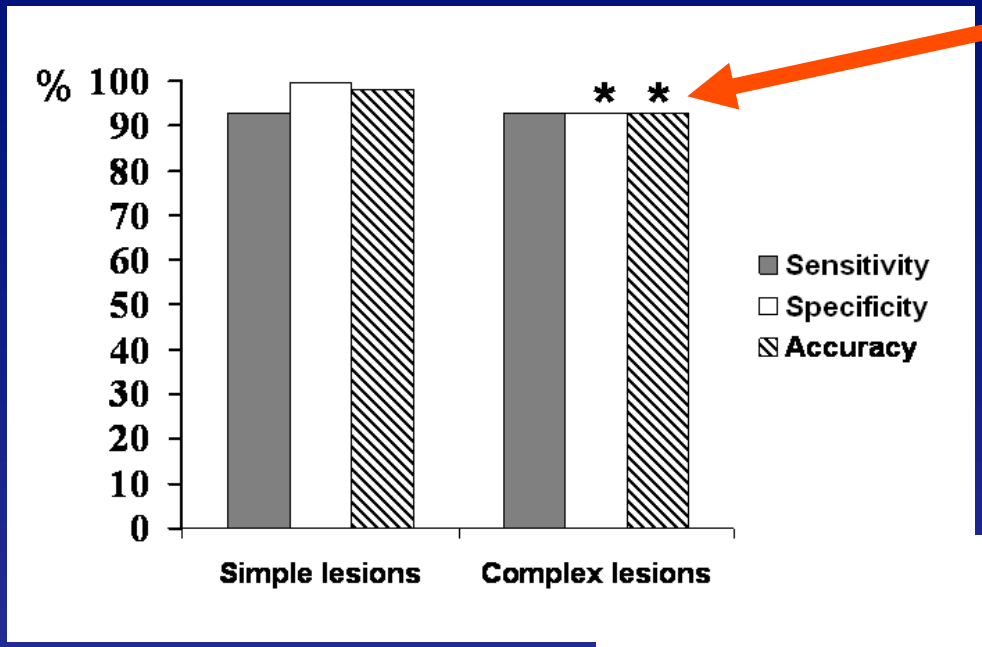
200 patients
3DTTE preop
2DTEE intraop
vs
Surgical
Inspection



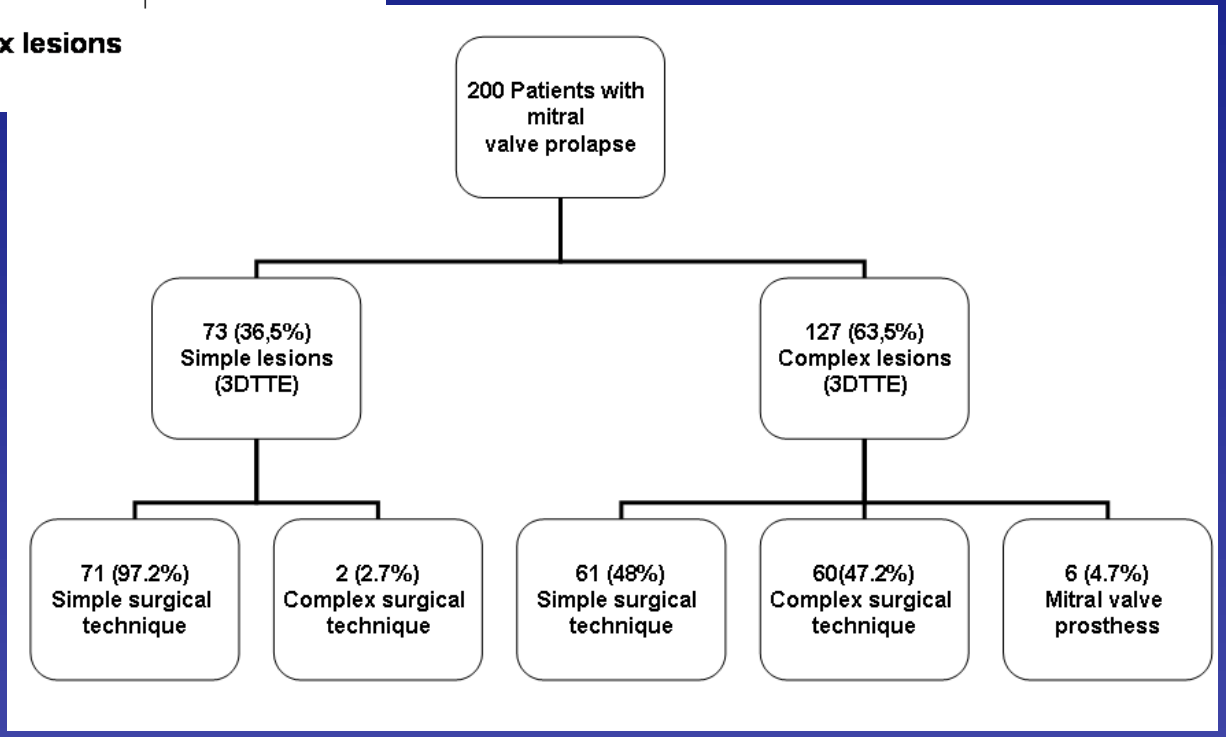
63% Complex



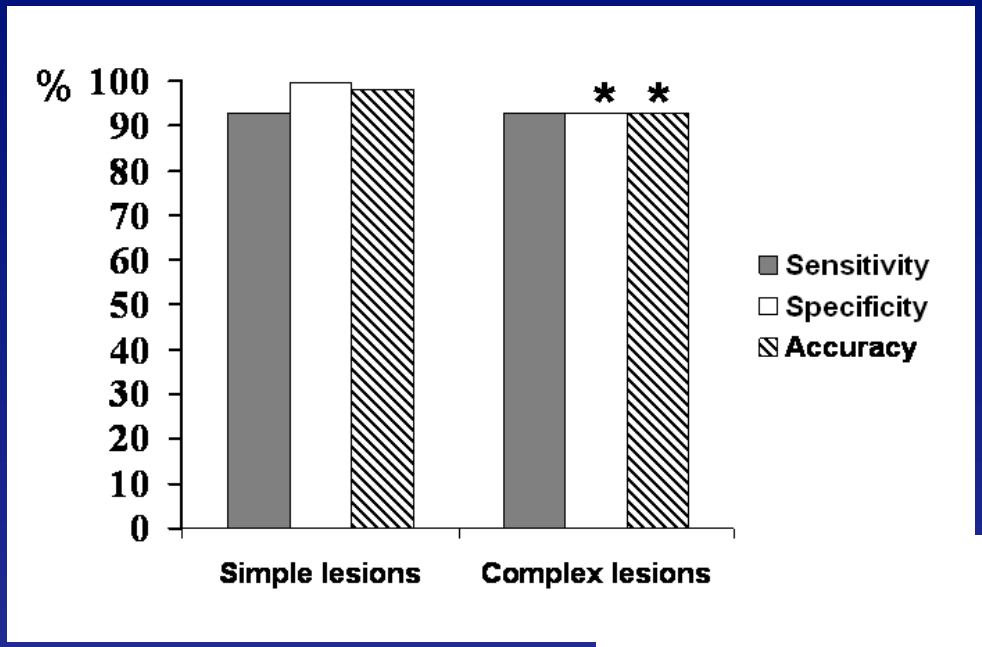
Tamborini et al. Eur J Echocard 2010



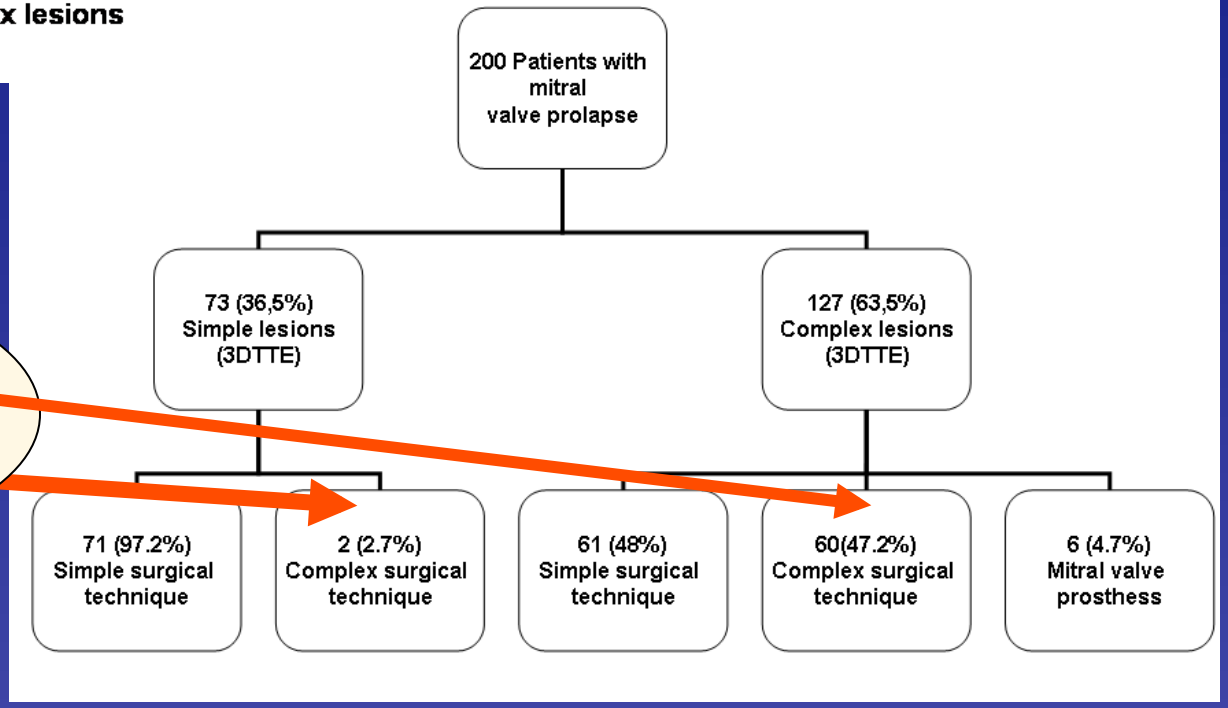
90% accuracy



Tamborini et al. Eur J Echocard 2010



Prediction



Tamborini et al. Eur J Echocard 2010

European Journal of Echocardiography Advance Access published May 20, 2010

European Journal of Echocardiography
doi:10.1093/ejechocard/jeq066

Pre-operative transthoracic real-time three-dimensional echocardiography in patients undergoing mitral valve repair: accuracy in cases with simple vs. complex prolapse lesions

Gloria Tamborini*, Manuela Muratori, Anna Maltagliati, Claudia Agnese Galli, Moreno Naliato, Marco Zanobini, Francesco Alamanni, Luca Salvi, Erminio Sisillo, Cesare Fiorentini, and Mauro Pepi

Centro Cardiologico Monzino, IRCCS, Department of Cardiovascular Sciences, University of Milan, Via Parea 4, 20138 Milan, Italy

Received 5 February 2010; accepted after revision 25 April 2010

Real-time transthoracic 3D : Rapid Diagnosis of simple and complex lesions .

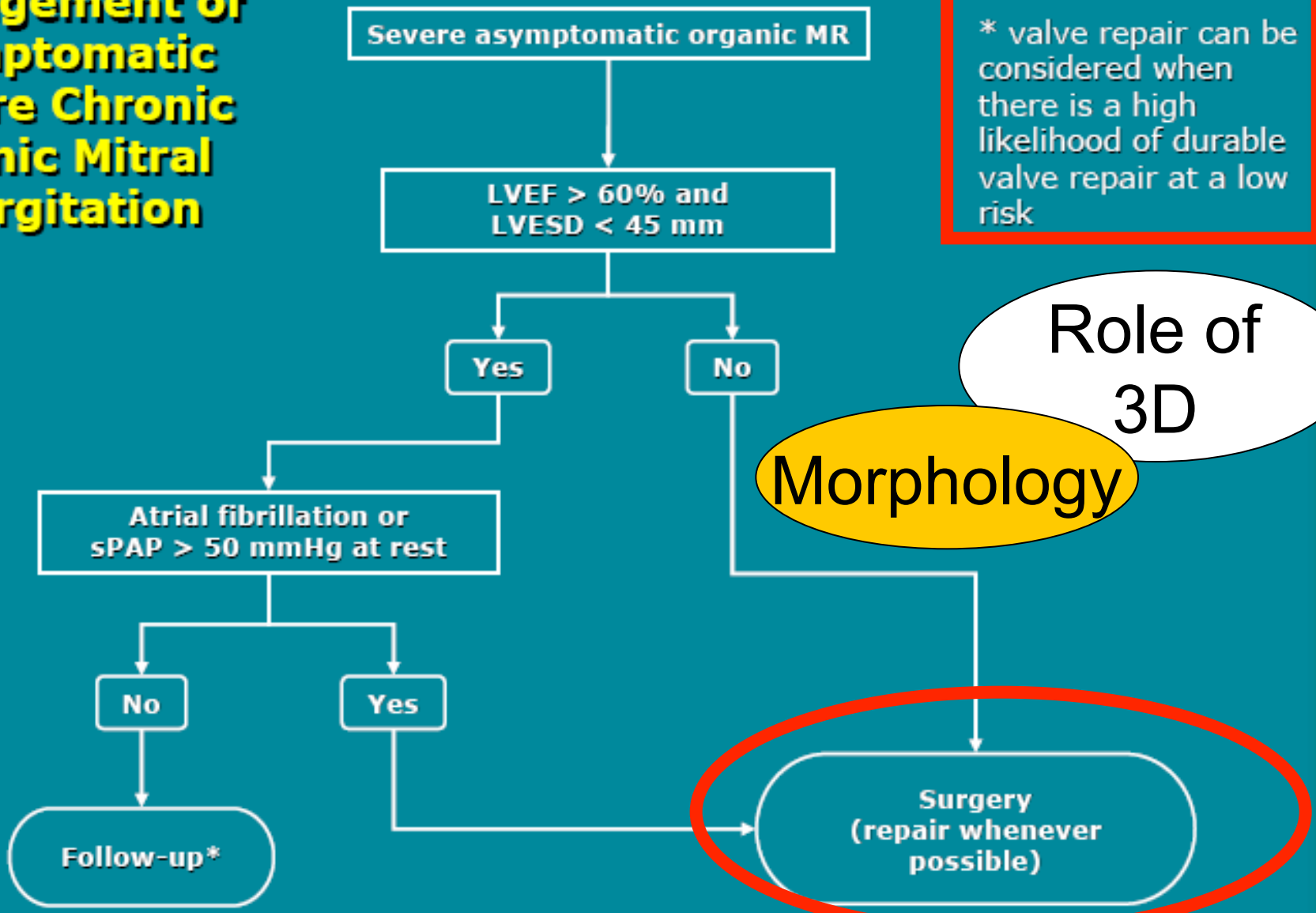
↓

May facilitate the prediction of the complexity of surgical procedures.

↓

May further facilitate the clinical decision and
the correct timing (early surgery vs delayed procedures) .

Management of Asymptomatic Severe Chronic Organic Mitral Regurgitation



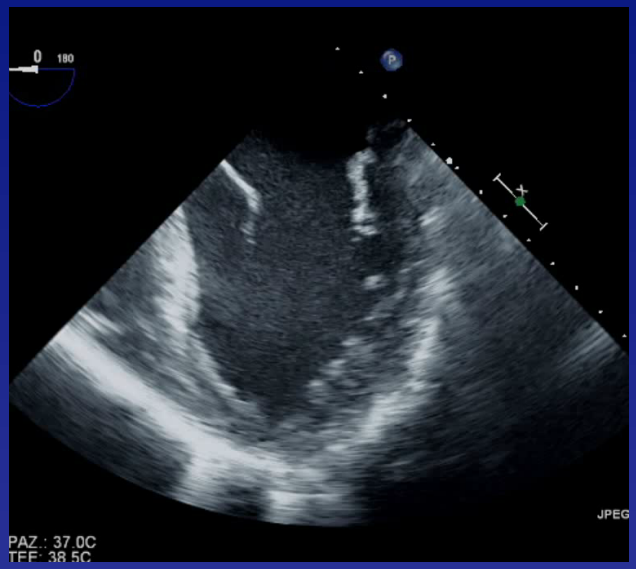
* valve repair can be considered when there is a high likelihood of durable valve repair at a low risk

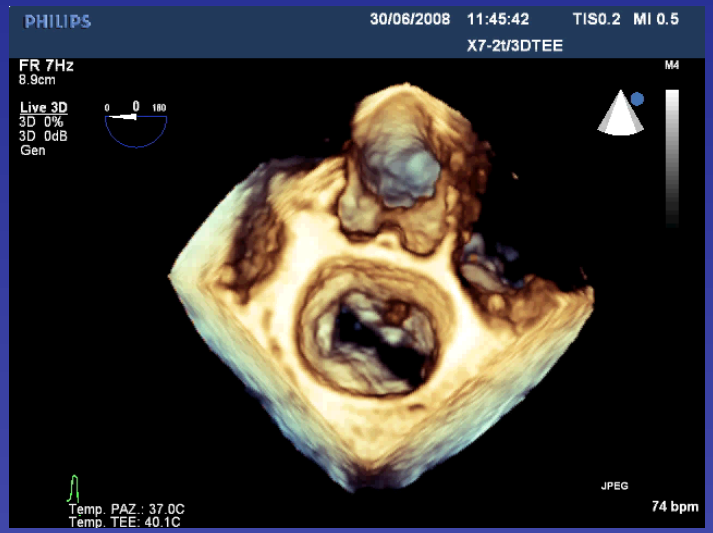
Role of 3D

Morphology

Intra-operatively

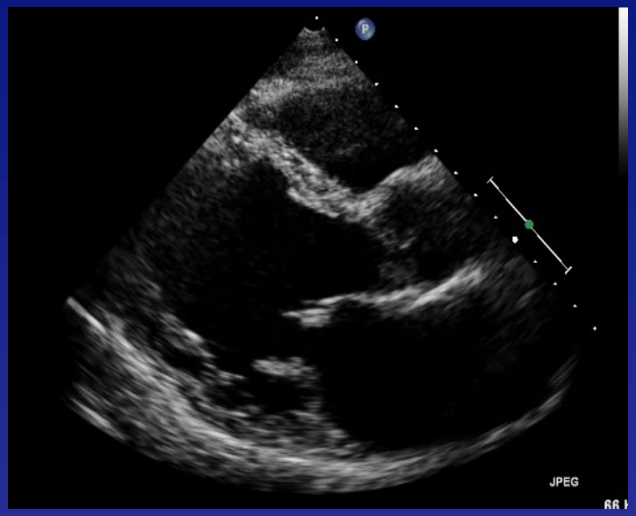
TEE

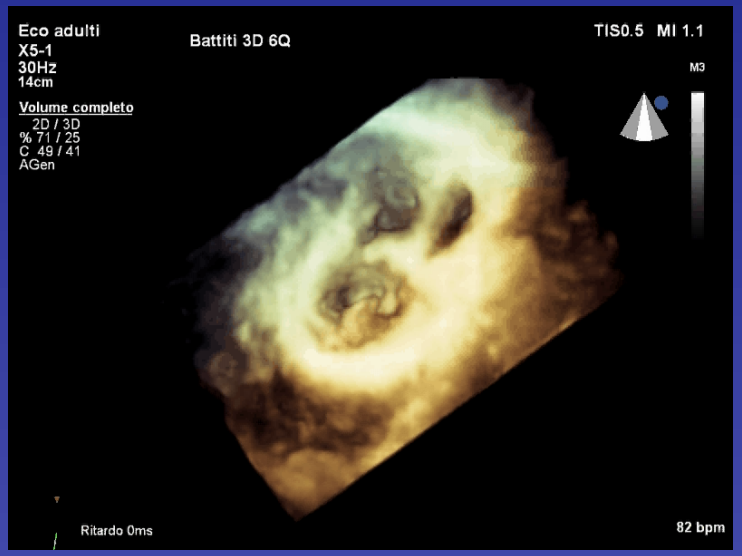




Pre-operatively

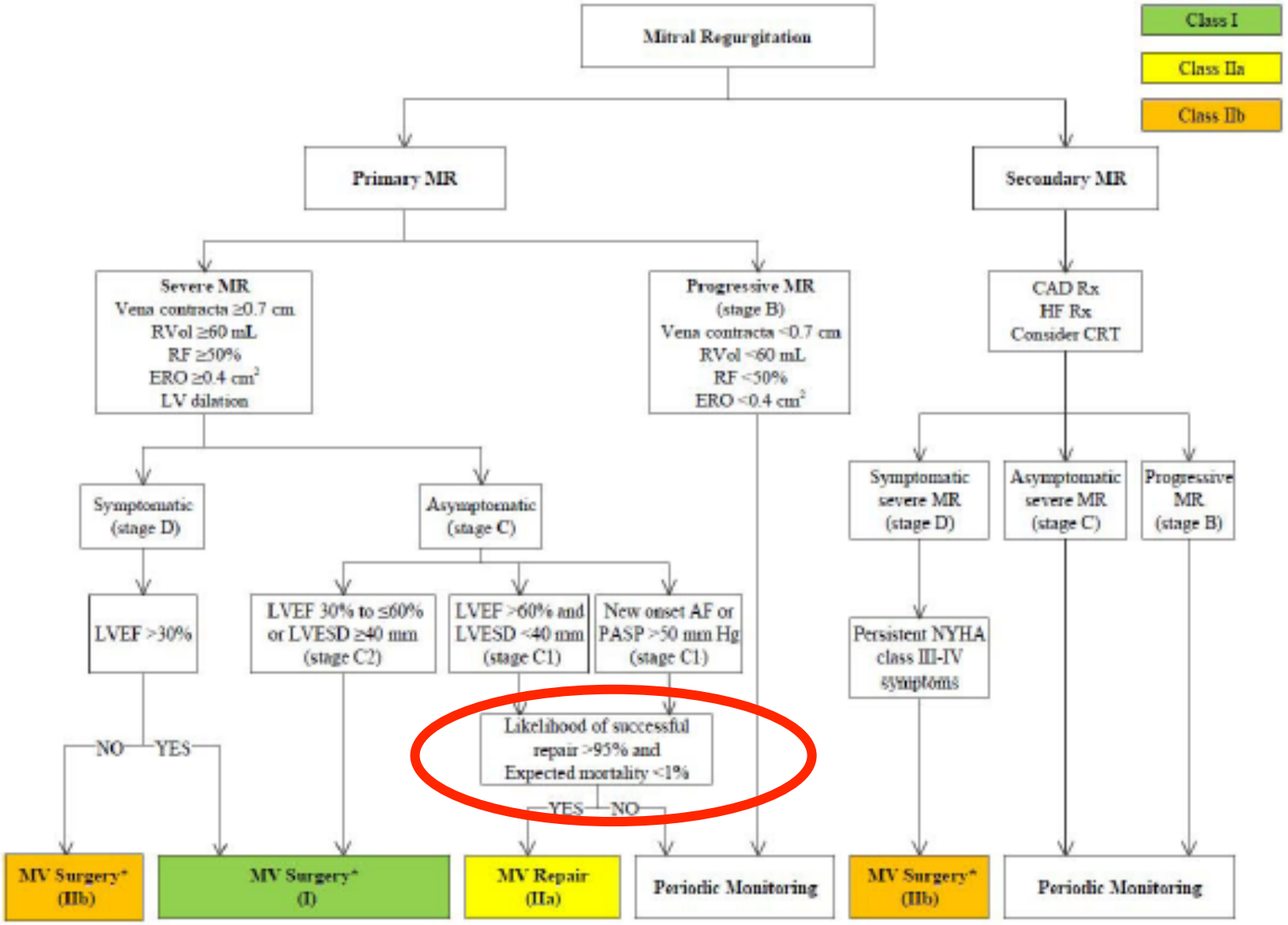
TTE





Nishimura, RA et al.
2014 AHA/ACC Valvular Heart Disease Guideline

2014 AHA/ACC



*Mitral valve repair is preferred over MVR when possible.

Table 17. Summary of Recommendations for Chronic *Primary* MR

Recommendations	COR	LOE	References
MV surgery is recommended for symptomatic patients with chronic severe primary MR (stage D) and LVEF ≥30%	I	B	(365, 376)
MV surgery is recommended for asymptomatic patients with chronic severe primary MR and LV dysfunction (LVEF 30%–60% and/or LVESD ≥40 mm, stage C2)	I	B	(359-362, 392-394)
MV repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR limited to the posterior leaflet	I	B	(87, 364, 395-409)
MV repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR involving the anterior leaflet or both leaflets when a successful and durable repair can be accomplished	I	B	(86, 407-413)
Concomitant MV repair or replacement is indicated in patients with chronic severe primary MR undergoing cardiac surgery for other indications	I	B	(414)
MV repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is >95% with an expected mortality rate of <1% when performed at a Heart Valve Center of Excellence	IIa	B	(39, 86, 415-419)
MV repair is reasonable for asymptomatic patients with chronic severe	IIa	B	(363, 415,

X

X MV repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is >95% with an expected mortality rate of <1% w (Center of Excellence)

Patients selection for MitraClip: Time to move to transthoracic echocardiographic screening?

Paola Gripari [a,1], Francesco Maffessanti [a,*,1], Gloria Tamborini [a], Manuela Muratori [a], Laura Fusini [a], Sarah Ghulam Ali [a], Cristina Ferrari [a], Francesco Alamanni [a,b], Antonio L. Bartorelli [a,b], Cesare Fiorentini [a,b], Mauro Pepi [a]

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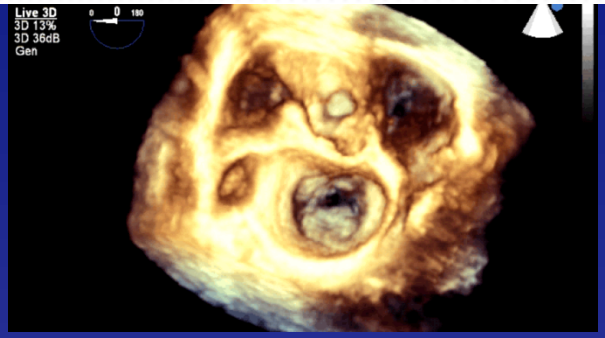
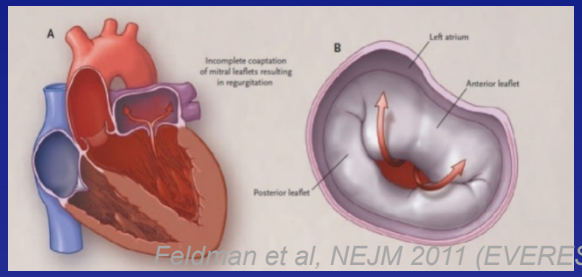
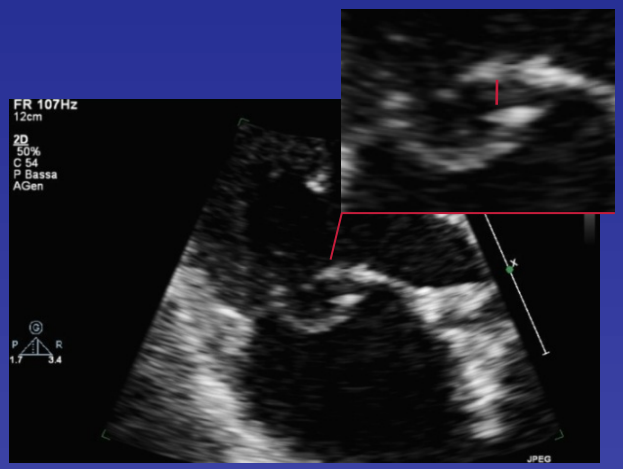
[b] Department of Clinical Sciences and Community Health – Cardiovascular Section, University of Milan, Milan, Italy

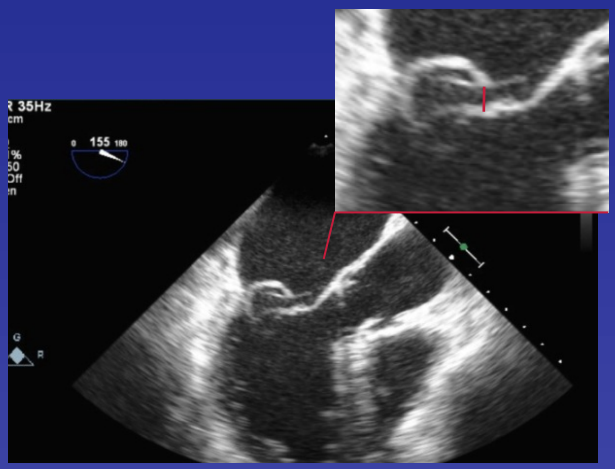


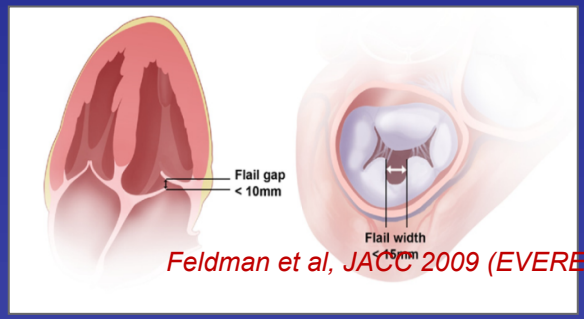


Feldman et al, NEJM 2011 (EVEREST II)

Flail Gap and Width





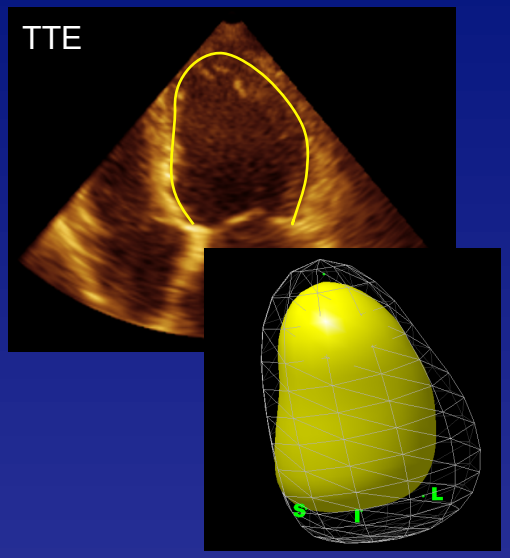


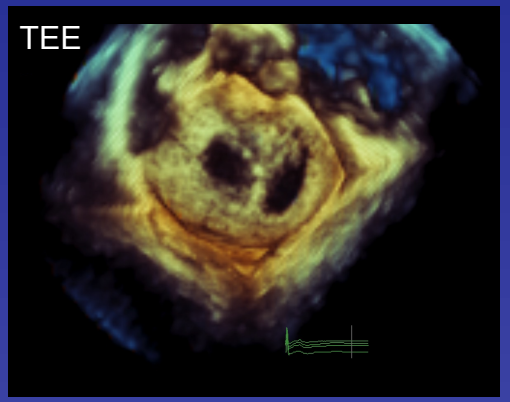
Feldman et al, JACC 2009 (EVEREST)

Anatomic criteria Degenerative MR

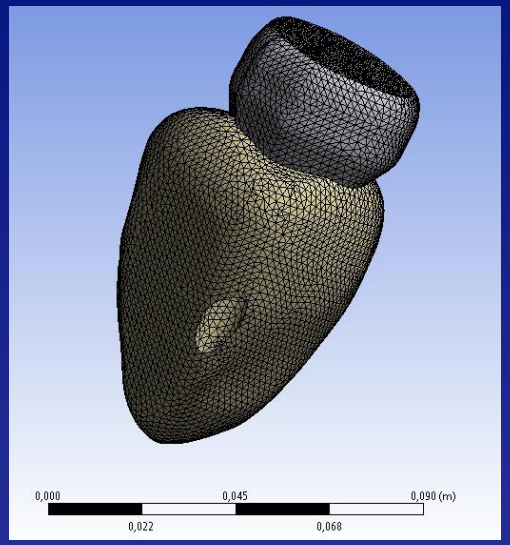
Advances in TTE and 3D echo may further improve our uderstanding of this new procedure

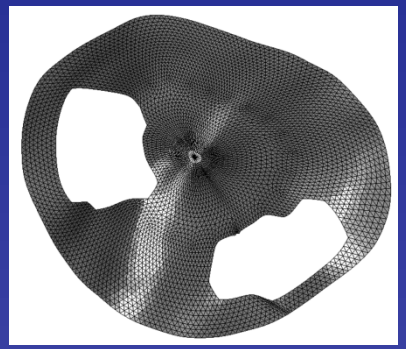
3D Echocardiography



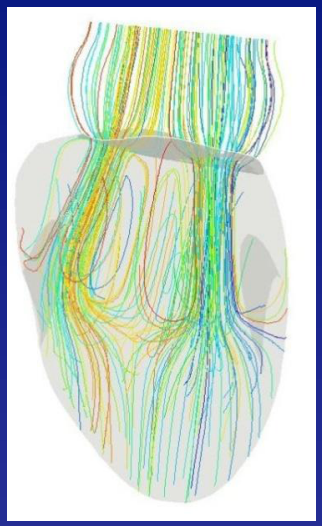


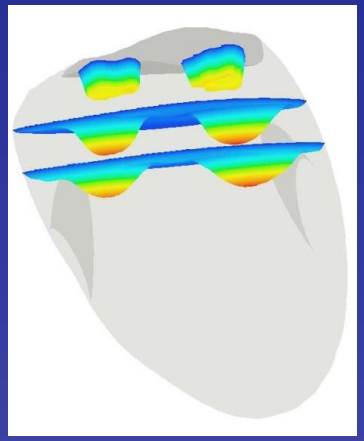
Patient specific model





Computational fluid dynamics





GUIDELINES AND STANDARDS

EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

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(J Am Soc Echocardiogr 2012;25:3-46.)

Three-dimensional TTE and TEE assessments of mitral valve pathology should be incorporated **into routine clinical practice** as they provide the best physiologic and morphologic information regarding the mitral valve. 3D TEE is recommended for guidance of interventional mitral valve procedures.