

*Quando il danno è già importante:*

*Insufficienza Mitralica Ischemica (IMI)*



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## *Insufficienza Mitralica Ischemica*

- *IMI è una insufficienza valvolare “funzionale”, infatti, diversamente dalle valvulopatie organiche, le anomalie del ventricolo sinistro non sono la conseguenza ma la causa della malattia valvolare*



# *Insufficienza Mitralica Ischemica (IMI)*

## *DEFINIZIONE*

*L'insufficienza mitralica ischemica (IMI) è la complicanza di una malattia coronarica, in particolare se manifestatasi con infarto (MI), e non la fortuita associazione tra malattia coronarica e IM ad altra etiologia (reumatica, degenerativa, endocarditica etc.)*

*L'insufficienza mitralica intermittente causata da ischemia transitoria è una condizione infrequente che va considerata come una manifestazione clinica della coronaropatia alla stregua dell'angina.*

# INSUFFICIENZA MITRALICA <sup>(1)</sup>

## ANATOMIA FUNZIONALE

*La completa ed omogenea coaptazione della superficie rugosa dei lembi e delle commissure lungo il piano dell'anello è garantita:*

- 1. Dall'integrità anatomica del tessuto valvolare*
- 2. Dalla contrazione dell'anello*
- 3. Dalla forza di trazione (**tethering**) dei muscoli papillari e del ventricolo sinistro*



## PREVALENZA

- ✓ *Subito dopo un IMA acuto il 17 – 55 % dei pazienti sviluppa IM*
- ✓ *Dei pazienti che eseguono il cateterismo nelle prime 6 ore dopo IMA acuto, il 18 % ha una IM ed il 3.4 % ha una IM severa*

*Hickey MStJ. Circulation 1988;78:1:*

- ✓ *Nel complesso l'IM è frequente subito dopo IMA acuto, ma in molti pz è lieve e tende a scomparire successivamente.*
- ✓ *L'elevata incidenza (10.9 % - 19 %) nei pazienti sottoposti a cateterismo per malattia coronarica sintomatica suggerisce che l'IM persiste cronicizzandosi o può formarsi ex novo.*

## *Meccanismi dell'IMI ACUTA*

### *- CON ROTTURA*

*Rottura del papillare ( il posteriore 3-6 volte più frequente dell'anteriore )*

### *- SENZA ROTTURA*

*La perdita dell'accorciamento dei muscoli papillari, da sola, non determina IMI.*

*L'IMI è causata da una complessa interazione di modificazioni geometriche e temporali molto piccole, difficili da rilevare con l'imaging o al momento della chirurgia a cuore flaccido.*

# MITRALE ISCHEMICA <sup>(4)</sup>

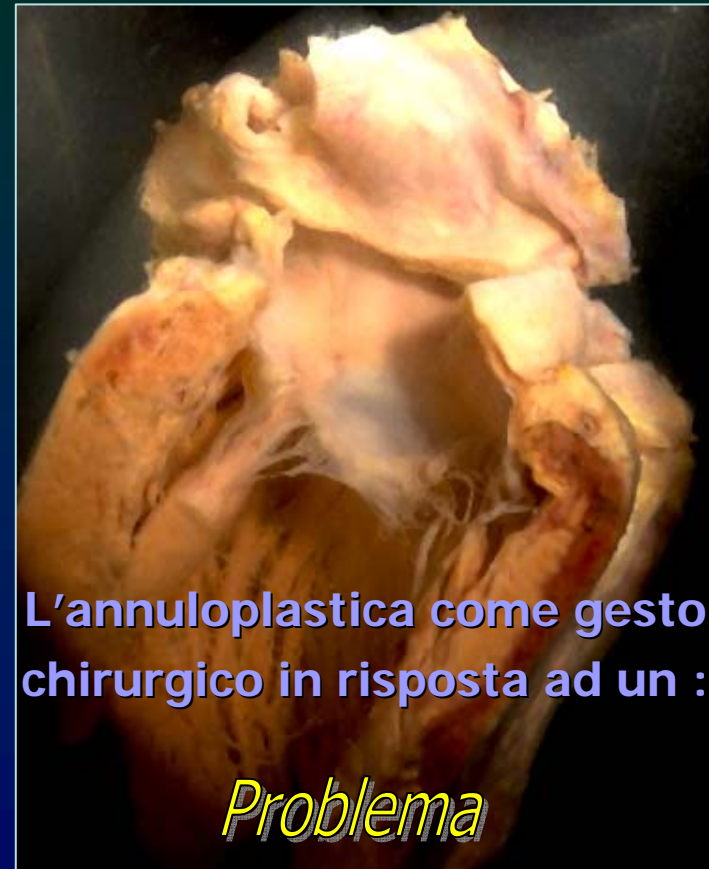
## Meccanismi dell'IMI CRONICA

*Sono ancora oggetto di controversie.*

- ✓ *L'IMI è una situazione complessa prodotta da modificazioni dell'anatomia, della geometria e della funzione dell'anello, del ventricolo e dei muscoli papillari*
- ✓ *Il meccanismo può differire da paziente a paziente*
- ✓ *Se, quando e con quale entità l'IMI si sviluppa dipende dalle dimensioni, dalla transmuralità e dalla sede dell'infarto*

# Mechanisms of IMR

- **Annular dilatation/deformation/dysfunction**
  - Septolateral dimension
  - Loss of 3D saddle shape
  - Loss of systolic sphincteric action
- **Valve distortion**
  - Leaflets tethering
  - Seagull effect
  - Reduced coaptation
- **LV dysfunction**
  - Closing forces reduction
  - Loitering effect
  - Papillary separation



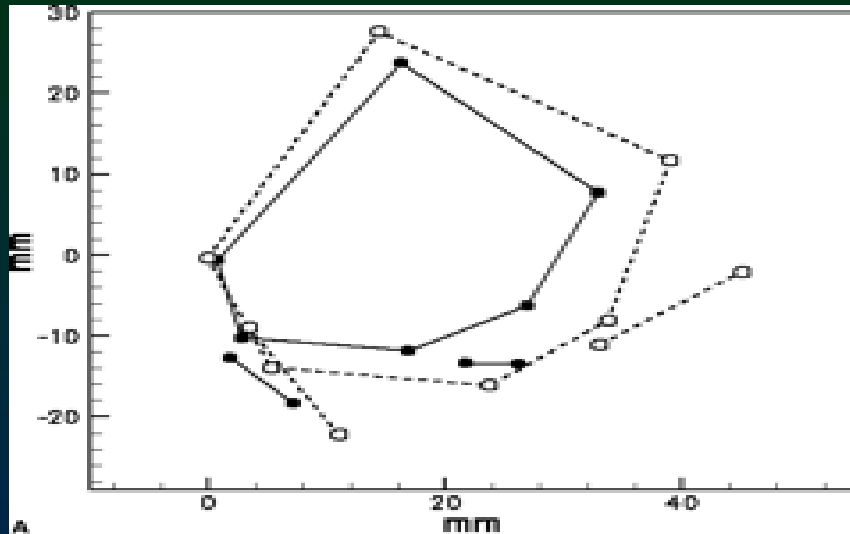
L'annuloplastica come gesto chirurgico in risposta ad un :

*Problema*

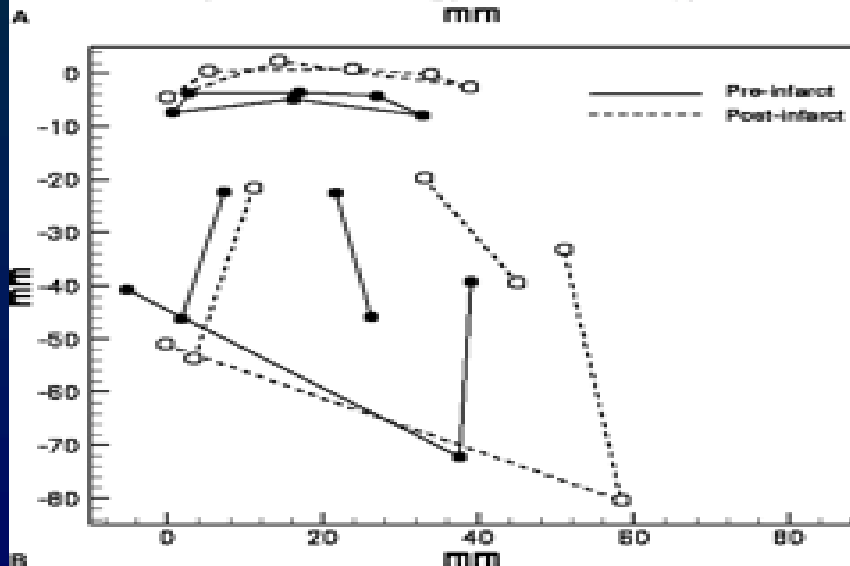
*Funzionale*



# Meccanismi dell'IMI CRONICA

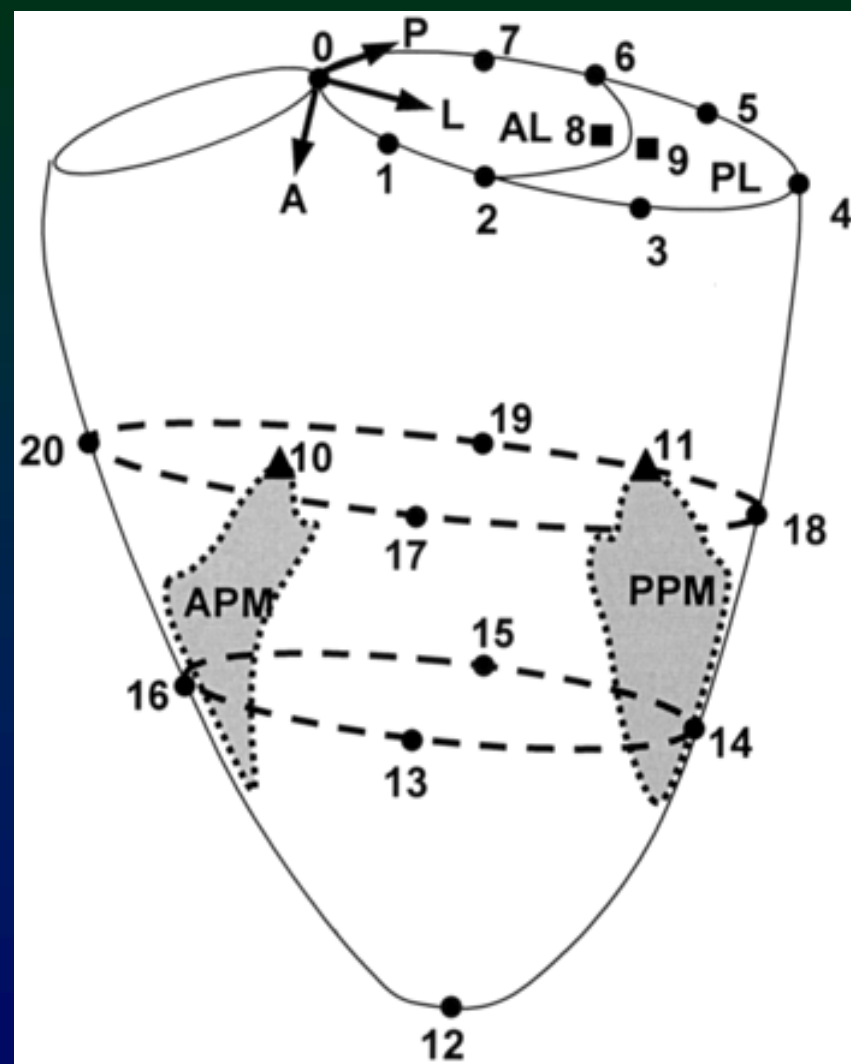


*Dopo infarto l'area anulare si dilata in sistole (60%) soprattutto a livello dell'anello muscolare.*



*La porzione posteriore dell'anulus, adiacente alla zona infartuata, si allontana dalla commissura anteriore (relativamente fissa perché in rapporto col trigono fibroso) trascinando la porzione anteriore dell'anello.*

# Mitrale Ischemica

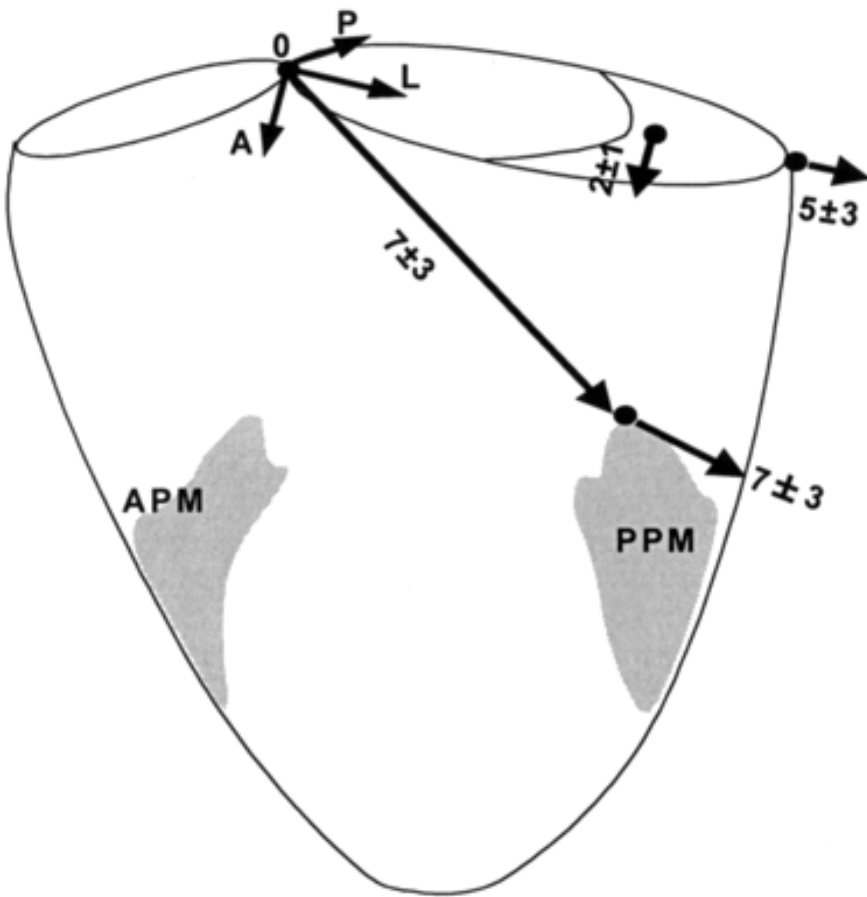


*Marcatori di tantalio visualizzati con videofluoroscopia*

*Tibayan FA Circulation 2003;108:1116-121*

# Mitrale ischemica

## CIMR(+) vs. CIMR(-)



## IMI cronica

*ANULUS: aumento del diametro setto-laterale*

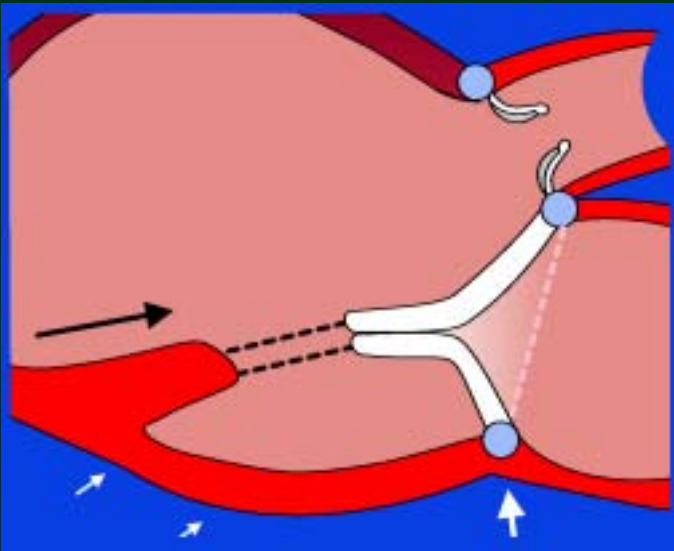
*GEOMETRIA DEI PAPILLARI: spostamento posteriore e laterale del mm. pap post con stiramento apicale del lembo*

## GEOMETRIA LEMBI

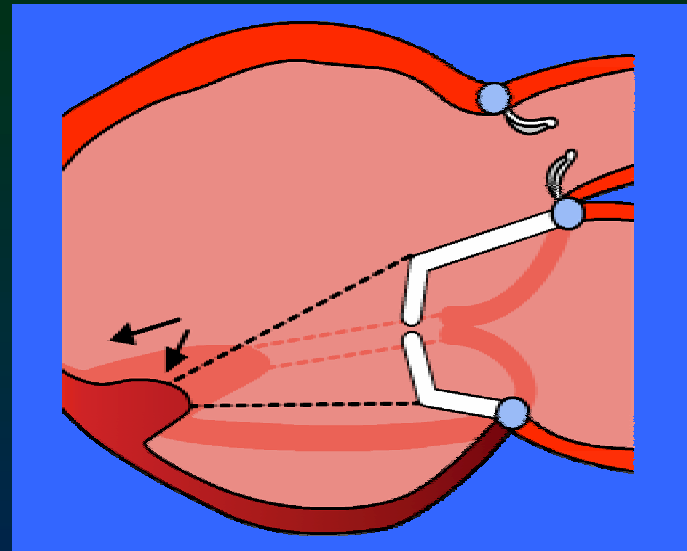
*Spostati in basso dal papillare con alterata coaptazione*

*Tibayan FA. Circulation 2003;108:II 116-121*

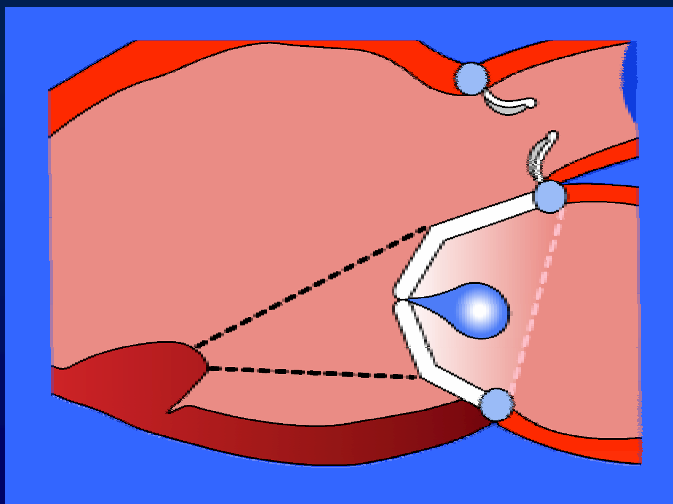
# Mitral Valve Closure



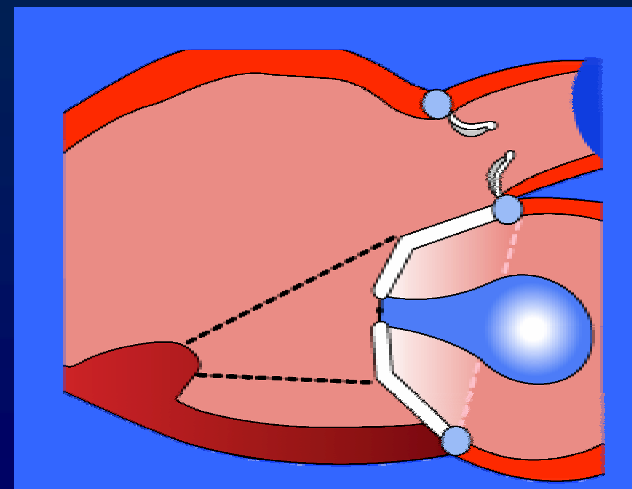
*Normal*



*Apical and post disp*



*Valve tenting*



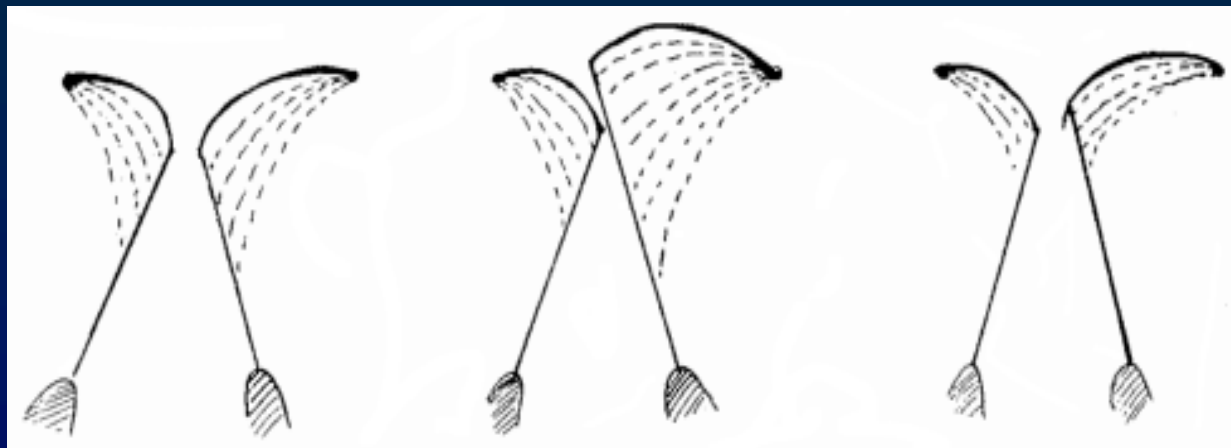
*Tenting + dilated annulus*

# *Classificazione Funzionale: Carpentier <sup>(1)</sup>*

*Tipo I : Movimento normale dei lembi*

*Dilatazione dell'annulus*

*Perforazione dei lembi*



**Tipo I**

**Tipo II**

**Tipo III**

## *Classificazione Funzionale: Carpentier (2)*

*Tipo II : Prolasso dei lembi, il margine libero supera il piano anulare durante la sistole*

*Rottura/elongazione delle corde tendinee*

*Rottura/elongazione dei muscoli papillari*



**Tipo I**

**Tipo II**

**Tipo III**

# *Classificazione Funzionale: Carpentier (3)*

*Tipo III: Restrizione del moto dei lembi  
I lembi non si aprono normalmente durante la diastole o non si  
chiudono durante la sistole*

*Fusione commissurale o ispessimento dei lembi*

*Fusione o ispessimento delle corde tendinee*



**Tipo I**

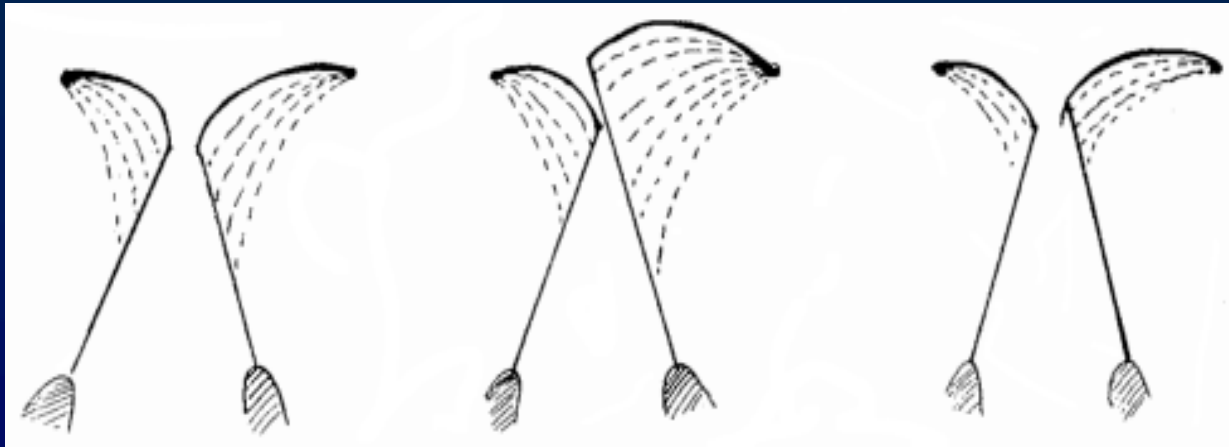
**Tipo II**

**Tipo III**

# *Classificazione Funzionale: Carpentier (4)*

*Tipo IIIa: restrizione del moto in diastole  
(stenosi), tipicamente di eziologia reumatica*

*Tipo IIIb: restrizione del moto sistolico dei lembi  
(rigurgito), tipicamente di eziologia ischemica*



**Tipo I**

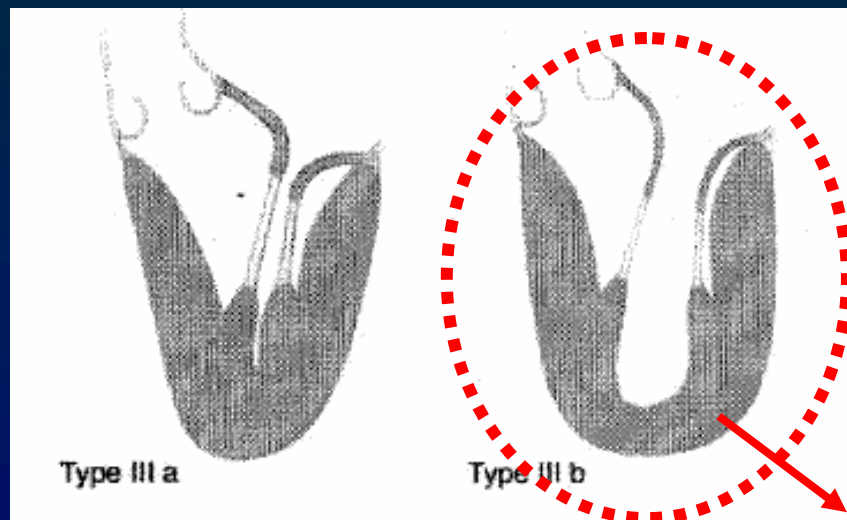
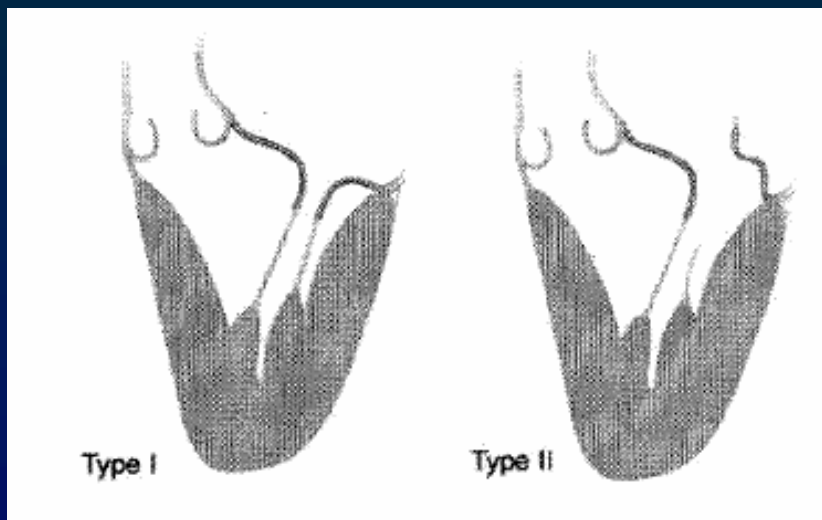
**Tipo II**

**Tipo III**

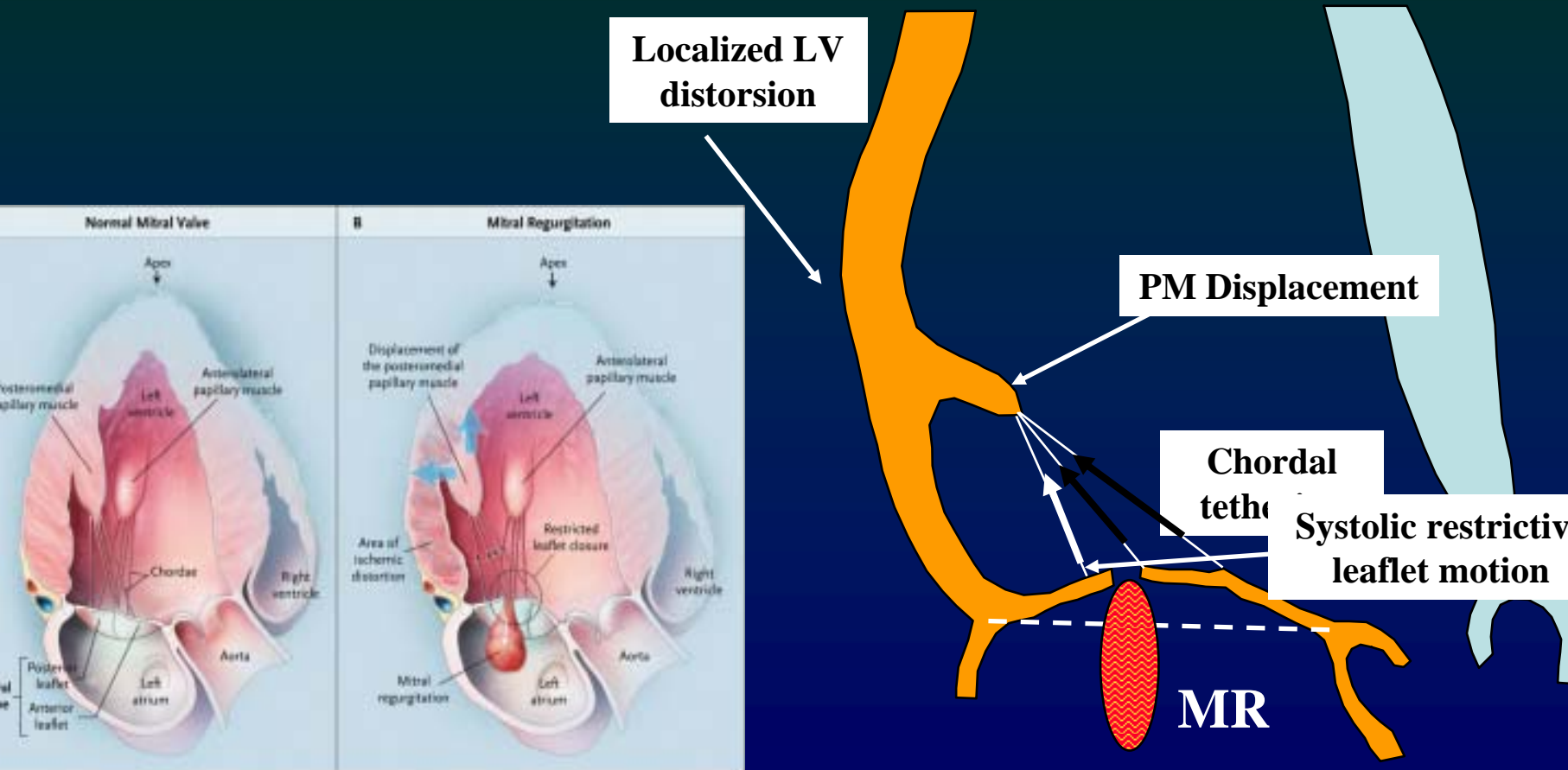


# Definizione dell' IMI

- Di solito i pazienti con IMI presentano una disfunzione **Tipo IIIb**, dovuta alla dislocazione dei mm. papillari per dilatazione ventricolare.



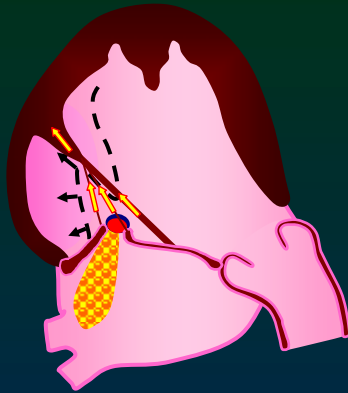
# From lesions to dysfunction (IIb)



# Echo Classification of IMR (type IIIb)

## ASYMMETRIC TETHERING:

Posterior  
tethering of both  
leaflets

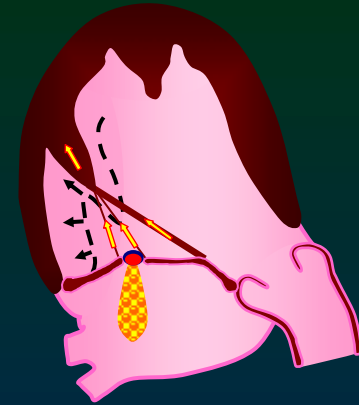


*Type IIIb post leaflet  
Central or commissural jet origin &  
posterior jet direction*

*Local LV distortion  
Tenting area & coapt. Height +  
Inferior prior MI  
PPM displacement  
LV Dilatation +  
EF --*

## SYMMETRIC TETHERING:

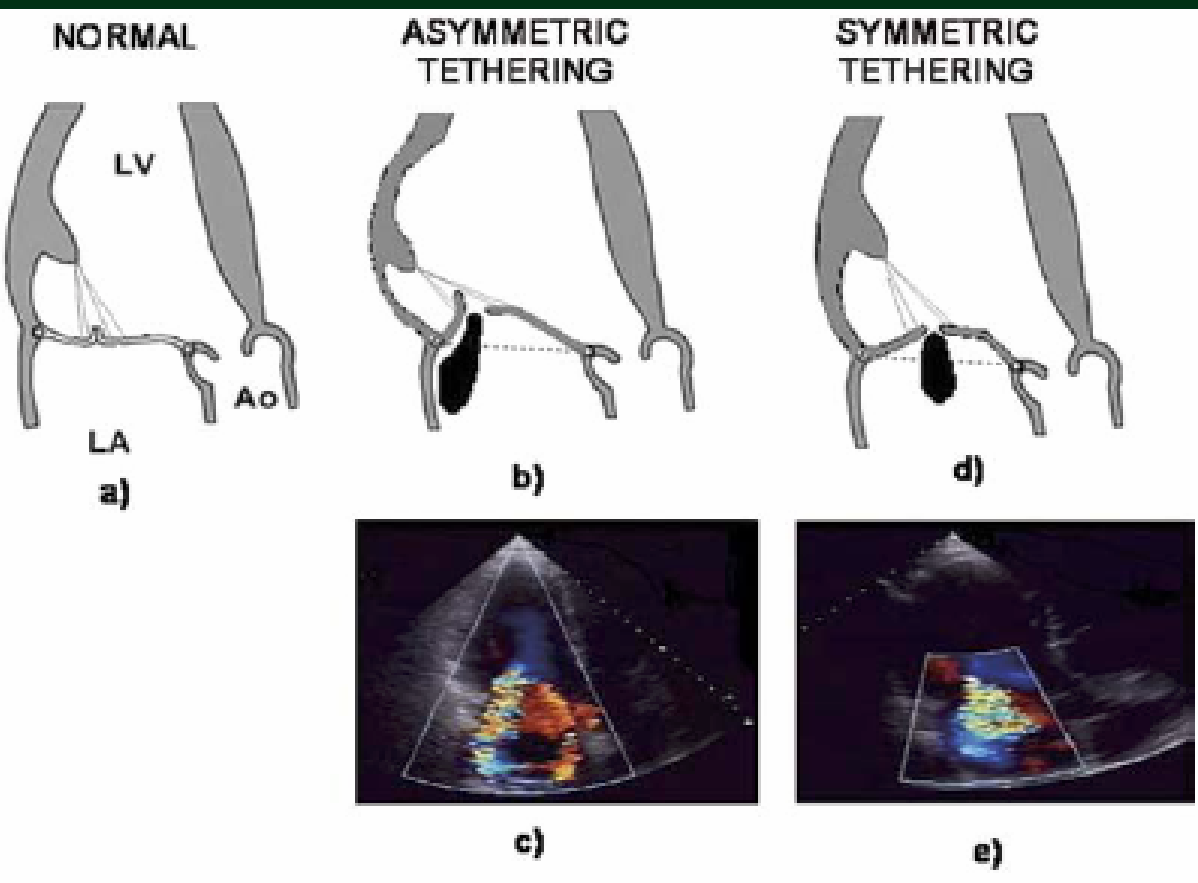
Apical tethering  
of both leaflets



*Type IIIb post and ant leaflet  
Central jet origin & direction*

*Global LV distortion  
Tenting area & coapt. Height ++  
Anterior prior MI  
PPM ± APM displacement  
LV Dilatation +++  
EF ----*

# IMI: correlazione tra Eco2D e patogenesi



- *Different surgical approach based on the characteristics of the regurgitant jet.*
  - *Asym tethering & commissural jet origin → undersized asym rigid ring*
  - *Sym or Asym Tethering & central jet origin → undersized sym rigid ring*

# IMI: valutazione di gravità

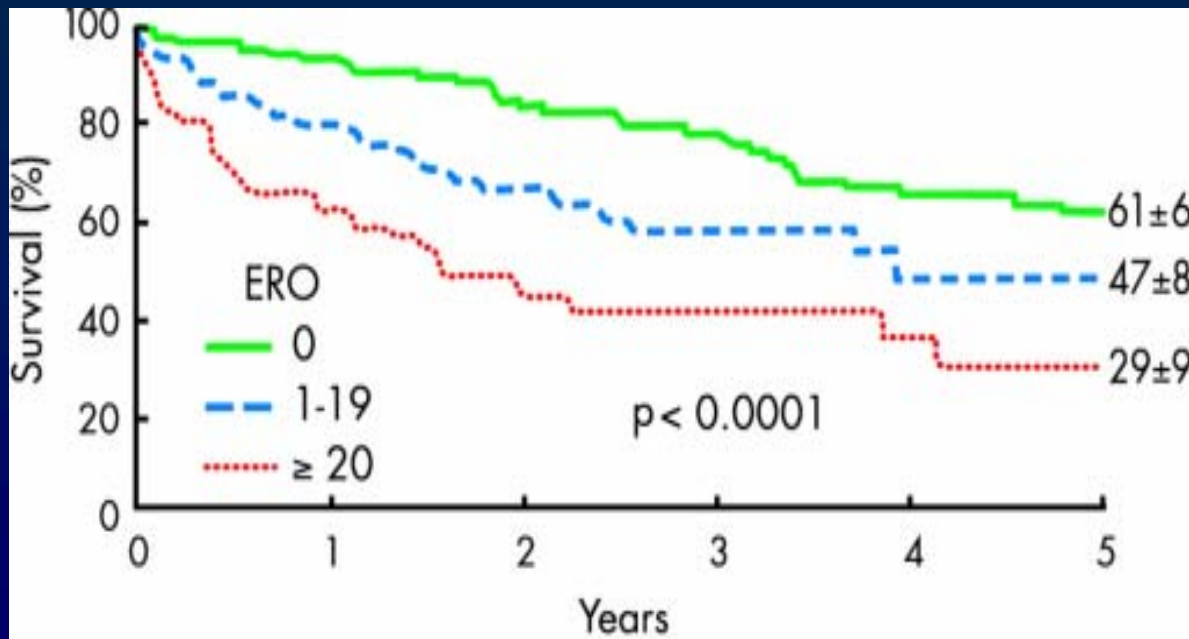
gli studi che hanno correlato la prognosi dell'IMI con

*Effective Regurgitant Orifice (ERO<sub>mm2</sub>)*

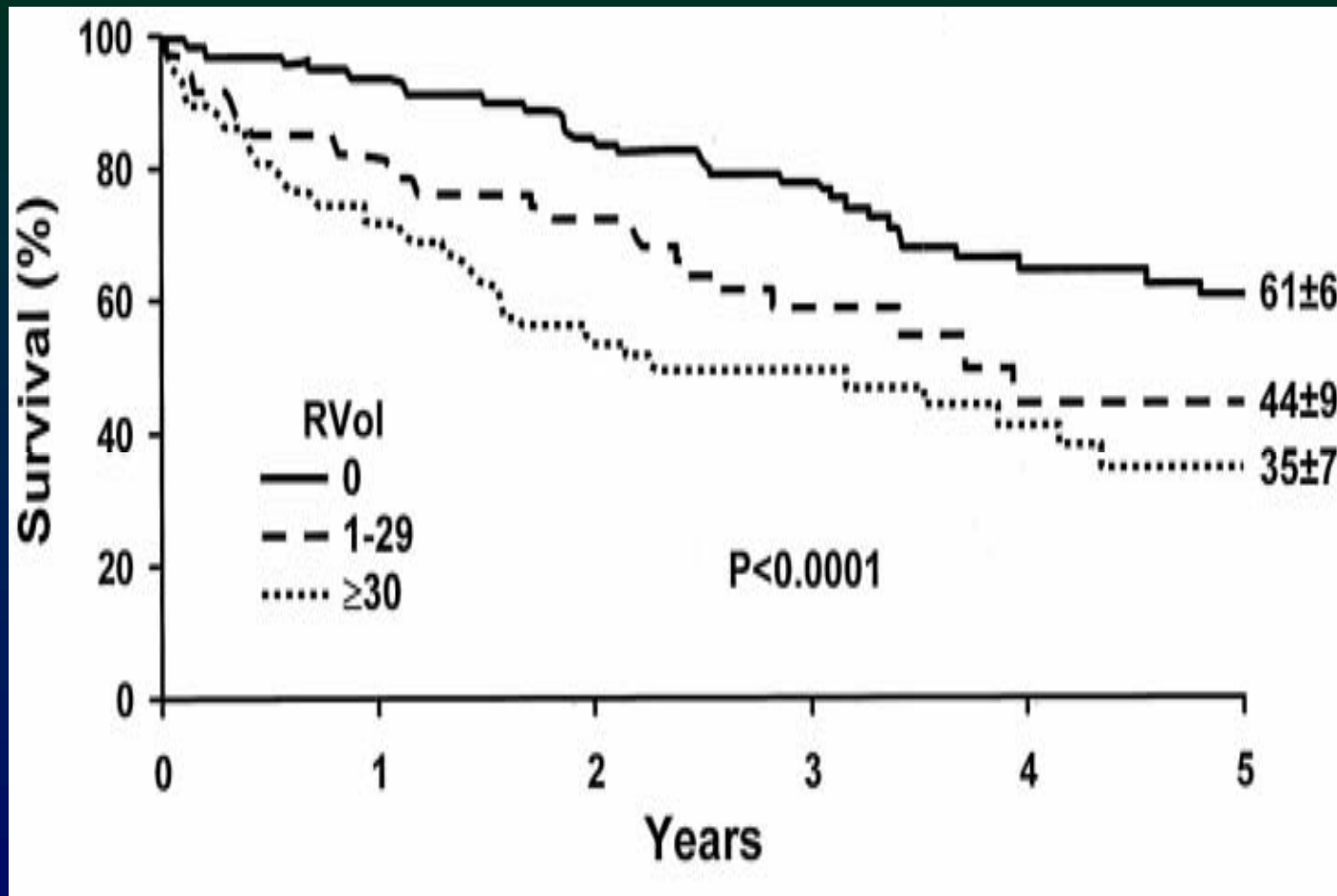
hanno dimostrato che la prognosi dell'IMI è infausta per valori di ERO che sarebbero "innocenti" in IM organica

*(Grigioni F - Circulation 2001)*

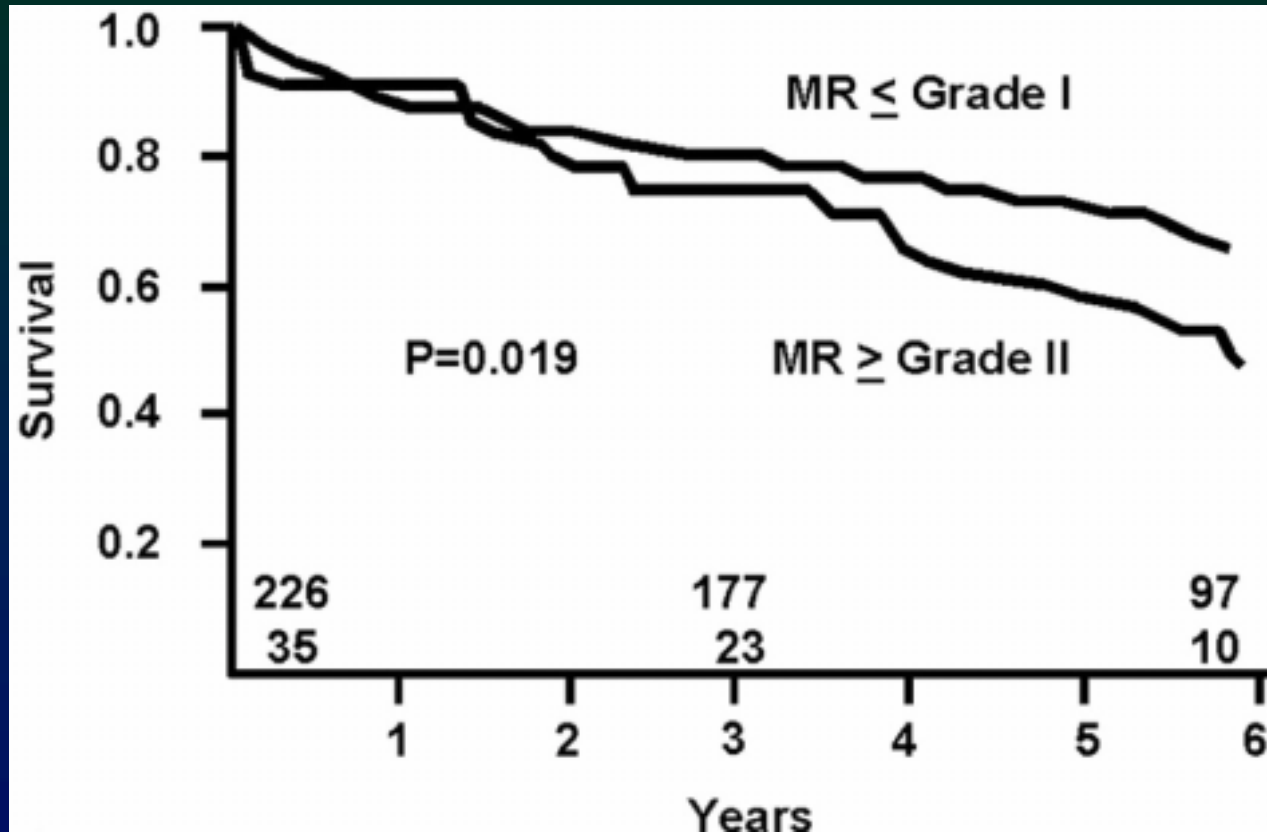
*Enriquez-Sarano et al. N Engl J Med 2005;352:875-83.*



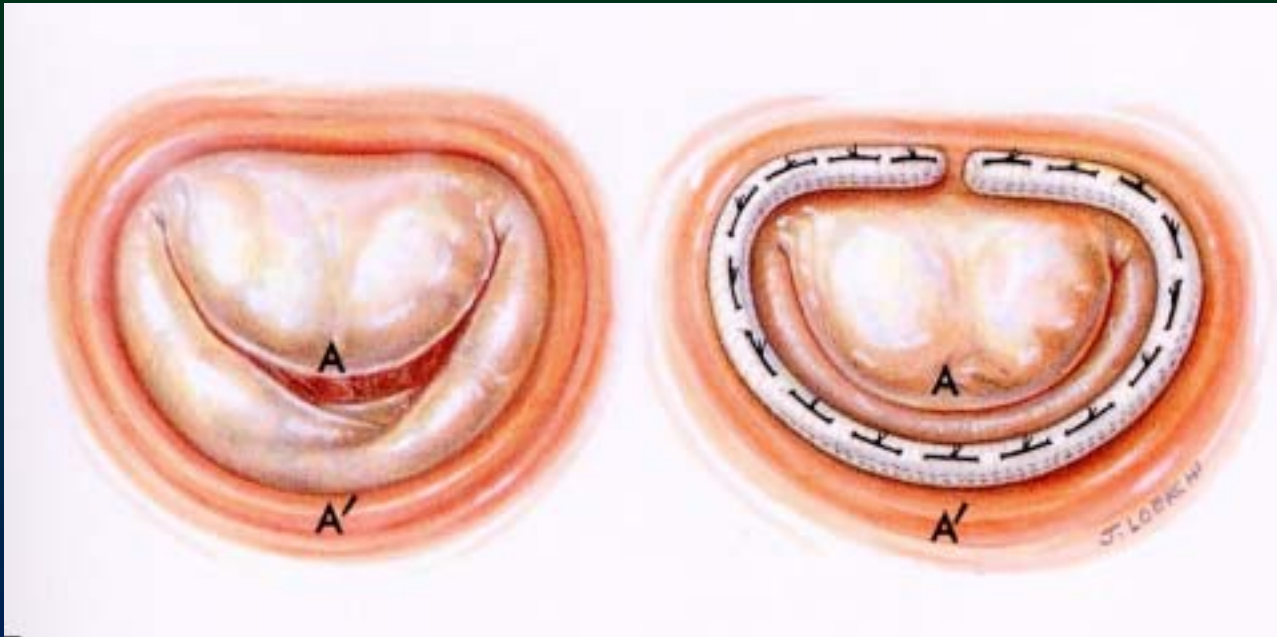
# IMI: correlazione tra volume di rigurgito (RV in ml / sistole) e sopravvivenza



*Importanza dell'IM residua postop :  
correlazione con la sopravvivenza*



# IMI: terapia *chirurgica*



*il rischio operatorio è correlato  
al grado di disfunzione del VS;  
non è aggravato  
dal gesto di riparazione della valvola*



# Rimodellamento anulare

- *Valvola Normale (A)*

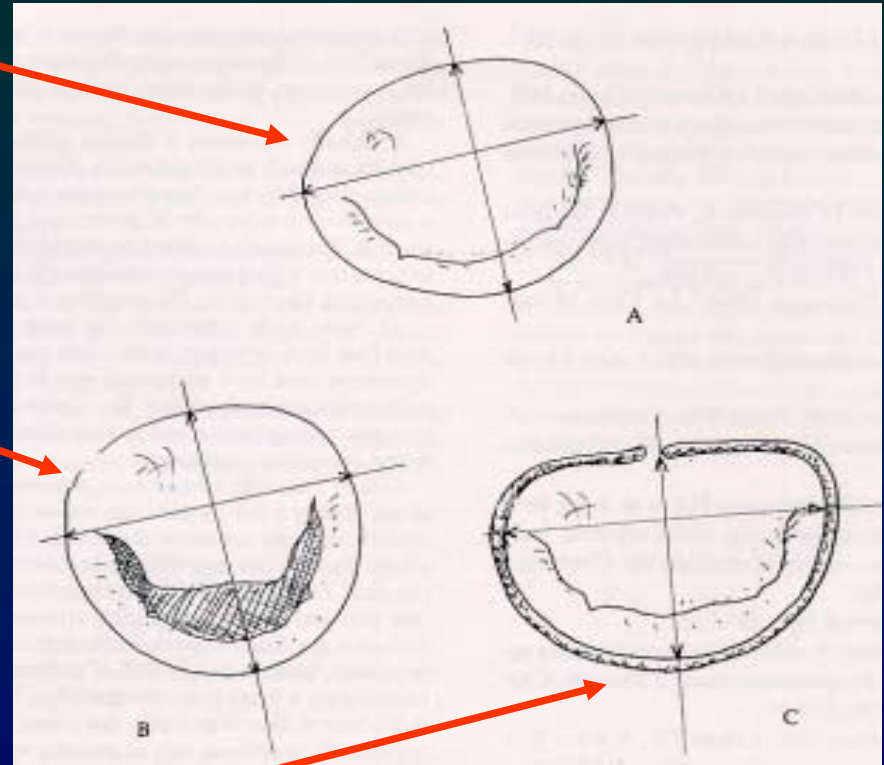
*Diametro Trasversale 33%  
più grande del diametro  
verticale*

- *Valvola Insufficiente (B)*

*Annulus deformato con  
diametro verticale  $\geq$  del  
diametro trasversale*

- *Valvola Rimodellata (C)*

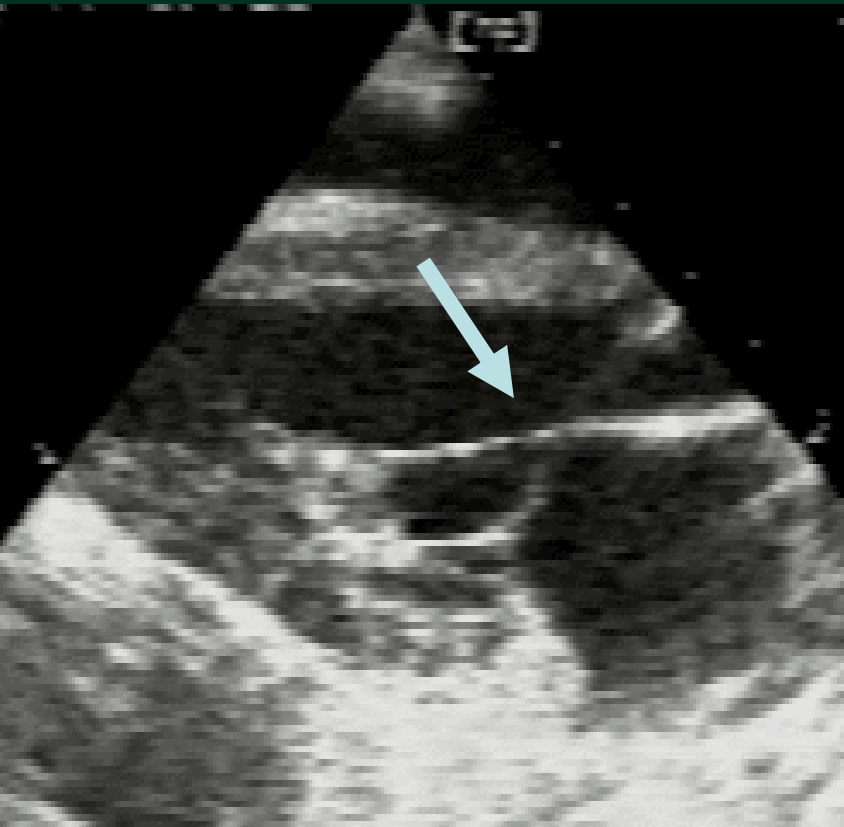
*Restaurato Rapporto 3:4*



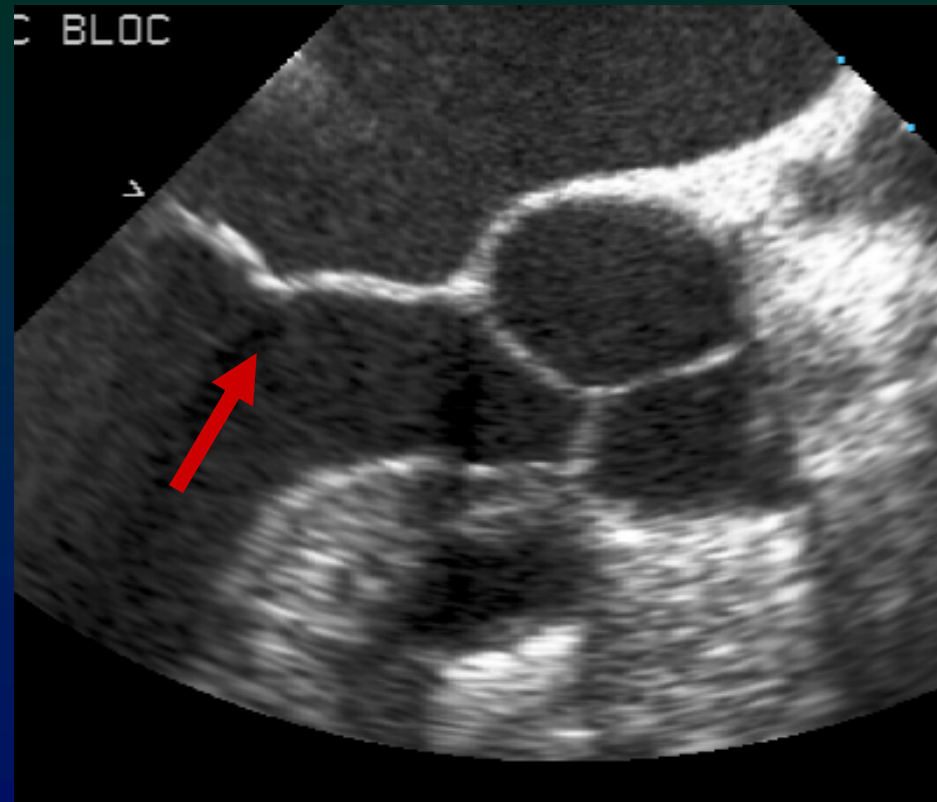
## *Quale direzione è importante?*

- *L'anuloplastica mitrale con anello ha dimostrato di correggere effettivamente IMI in studi clinici e sperimentali, molto probabilmente facilitando la coaptazione tra i lembi riducendo la dimensione antero-posteriore*
- *Questa dimensione è la principale direzione di allargamento dell'anulus*

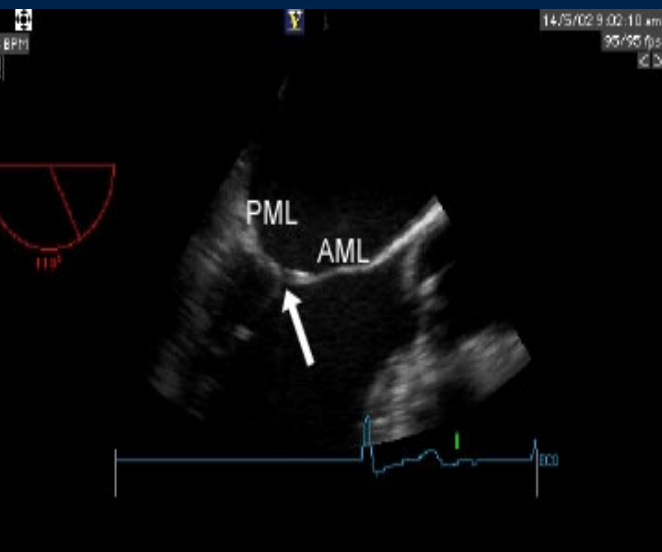
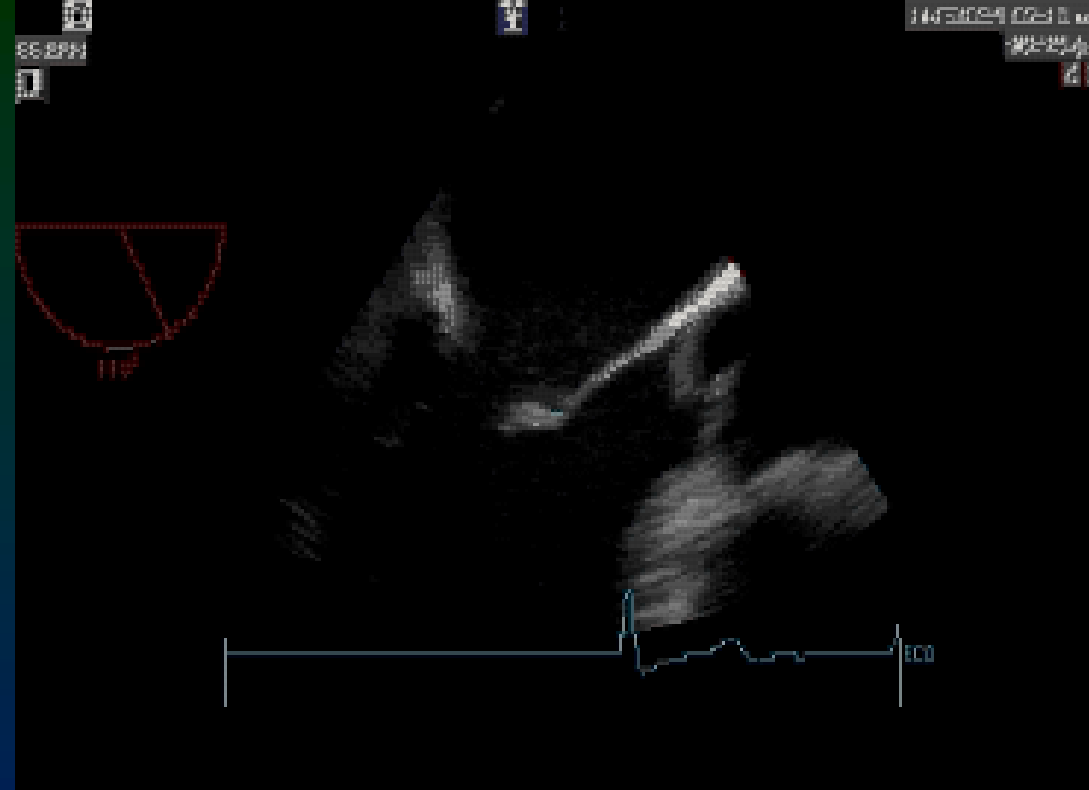
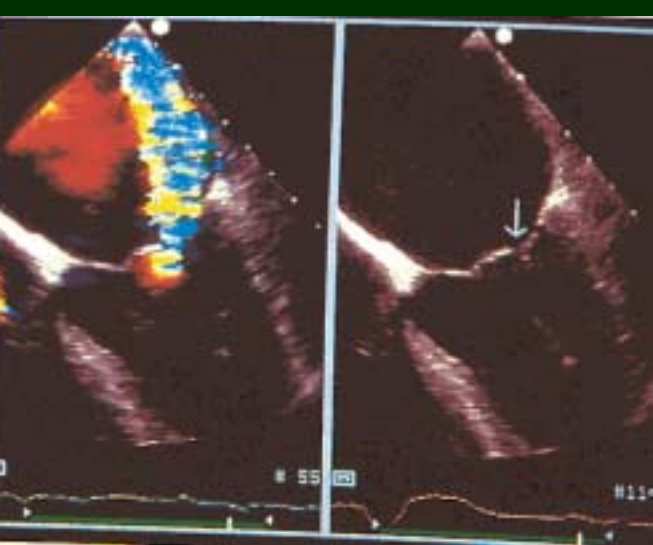
# « Seagull sign »



**TTE**



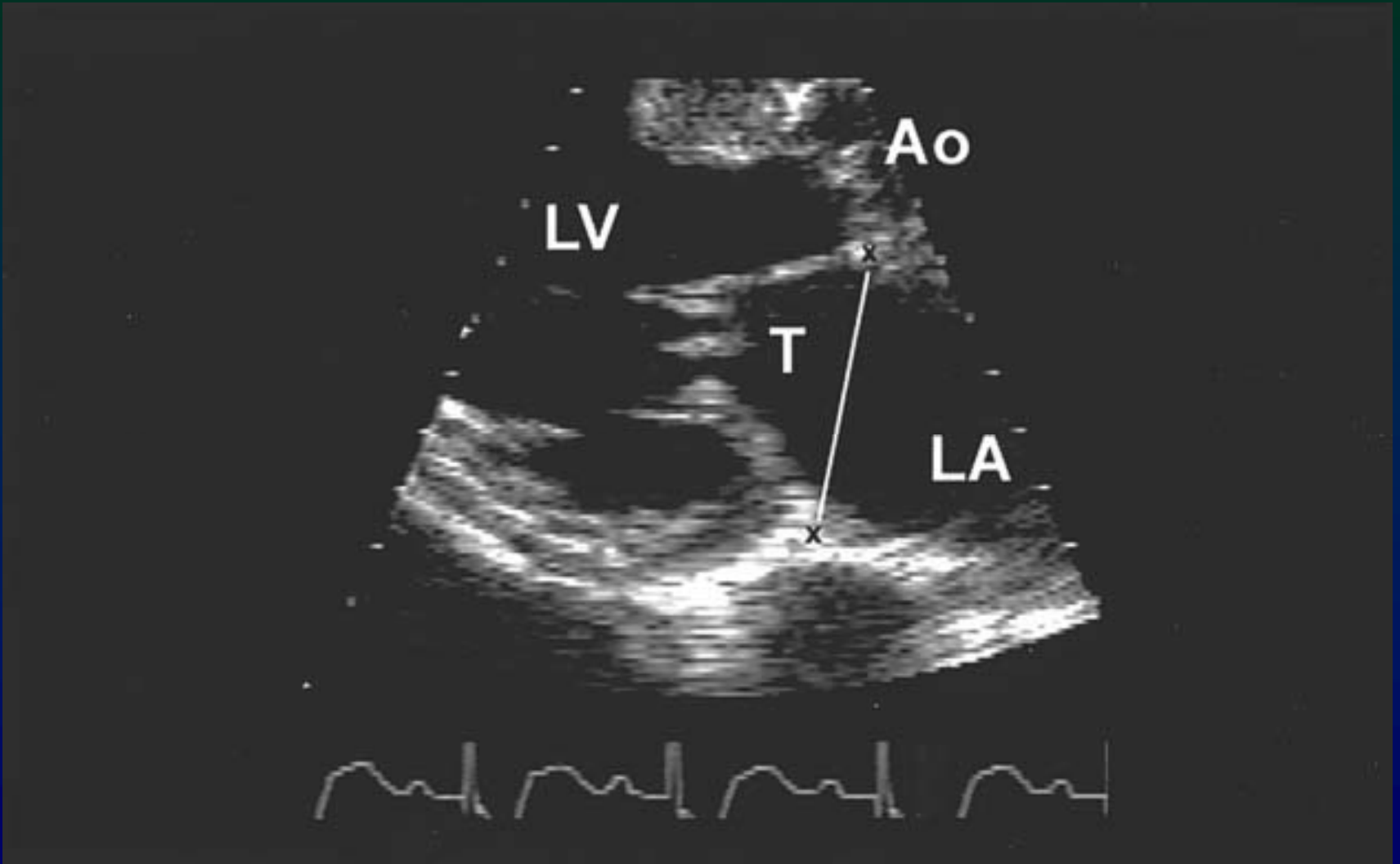
**TEE**





# IMI NEI PAZIENTI CON DISFUNZIONE SISTOLICA

(*YIU SF Circulation* 2000;102:1400)



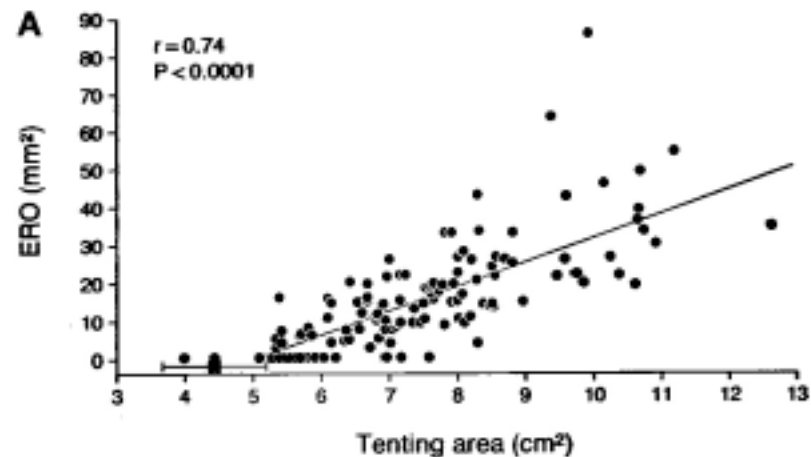
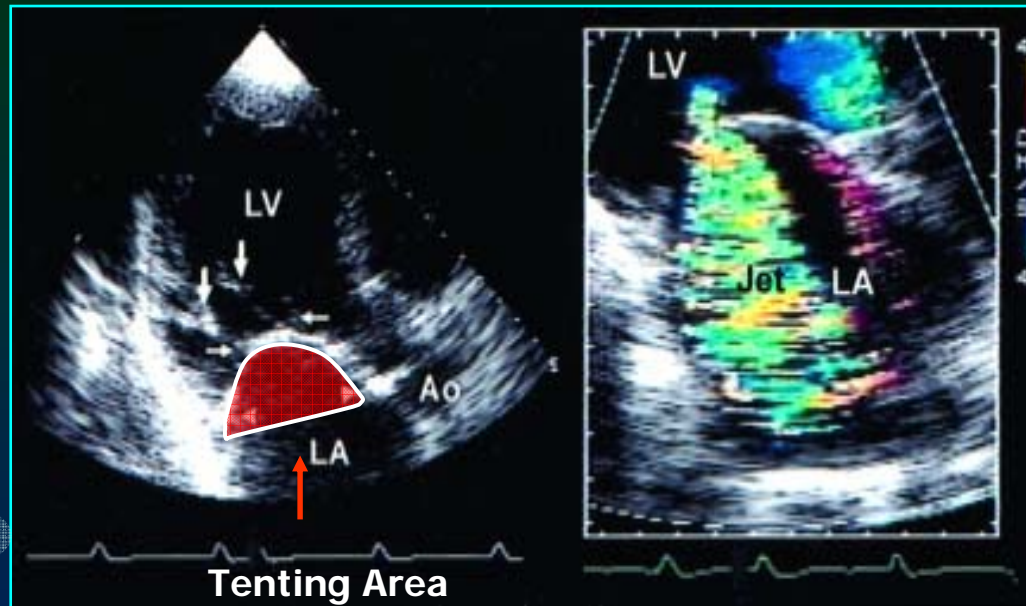


# Tethering effect, Tenting Area and ERO

The present study of humans with a wide range of LVD and FMR shows that apical and posterior displacements of the papillary muscle are the main determinants of tenting and FMR. LV remodeling for any given LV volume may have different local effects and result in different tenting and FMR.<sup>7,8</sup> For example, in the present series, 2 patients with similar EDVI (202 and 206 mL/m<sup>2</sup>) and EF (30% and 23%) had very dissimilar apical (7.9 versus 6.4 cm) and posterior (3.5 versus 2.9 cm) displacements of papillary muscle, resulting in widely different tenting areas (8.3 versus 7.7 cm<sup>2</sup>) and ERO (34 versus 18 mm<sup>2</sup>). Therefore, local LV remodeling, although related to global LV changes, is the strongest independent determinant of FMR degree and explains its wide range. Lower blood pressure may also contribute to larger ERO through decreased coaptation pressure.<sup>35</sup>

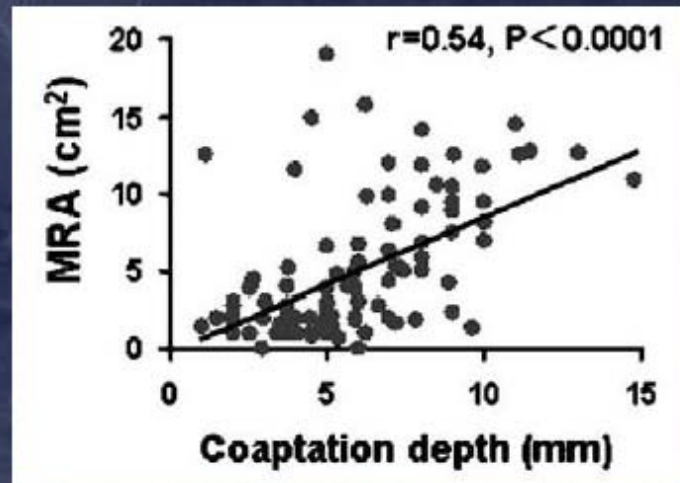
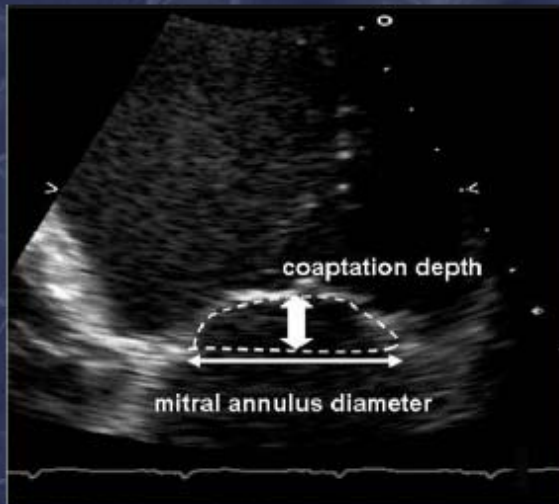
## Conclusions

FMR is a frequent complication of LVD but displays a wide range of degree. Higher ERO of FMR is associated with the loss of annular function and most strongly with excess mitral valvular tenting, which is determined by the degree of local LV remodeling (apical and posterior displacement of papillary muscle), independent of global LV remodeling. These



# Coaptation Depth

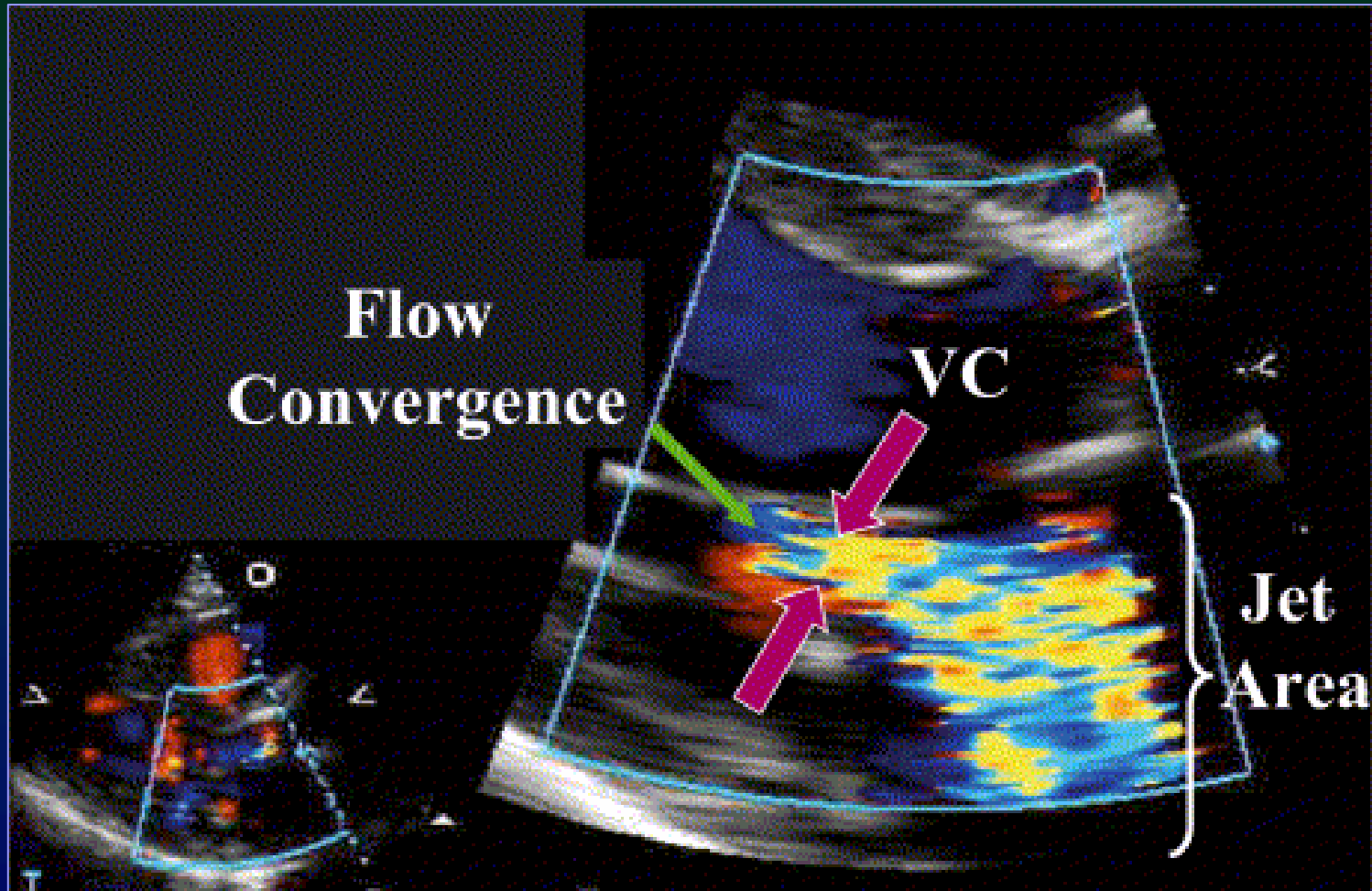
## Coaptation Depth Correlates with Ischemic MR



*Nagasaki et al: Int J Cardiol 2006; 108(2):171-6*



# *Regurgitant Jet: 3 components*



## *Quantification of Ischemic Mitral Regurgitation:*

*Severe MR*

*Organic*

*IMR*

*R vol*

*60 ml*

*30 ml*

*ERO*

*40 mm<sup>2</sup>*

*20 mm<sup>2</sup>*

*VCW*

*7 mm*

*4 mm*

# PARAMETRI ECOCARDIOGRAFICI PREDITTIVI DI SCARSO SUCCESSO CHIRURGICO

<i>FE</i>	$\leq 50 \%$
<i>FS</i>	$< 31 \%$
<i>Diametro tele-sistolico</i>	$> 45 \text{ mm}$
<i>Diametro tele-diastolico</i>	$> 70 \text{ mm}$
<i>Indice Volume tele-sistolico</i>	$> 50 \text{ mL/m}^2$
<i>Stress tele-sistolico</i>	$> 195 \text{ mmHg}$
<i>Stress ts/IVts</i>	$\leq 2,6$
<i>Pressione polmonare media</i>	$> 20 \text{ mmHg}$
<i>dP/dt del rigurgito al Doppler</i>	$< 1343 \text{ mmHg/sec}$

# INSUFFICIENZA MITRALICA ISCHEMICA

*La prognosi è legata alla cardiopatia di base*

*- Timing ?*

*- Severa se ERO  $\geq 20\text{mm}^2$*

*- Mortalità operatoria 10%*

*- Sopravvivenza a 5 anni 50%*

# Outcome after Mitral Valve Repair for Functional Ischemic Mitral Regurgitation

Stephen A. Tahta, James H. Oury, J. Matt Maxwell, Stephen P. Hiro, Carlos M.G. Duran

*The International Heart Institute of Montana and University of Montana, Missoula, Montana, USA*

**100 consecutive pts undergoing CABG also received a mitral valve repair.**

**A flexible ring (Duran) was used in all patients.**

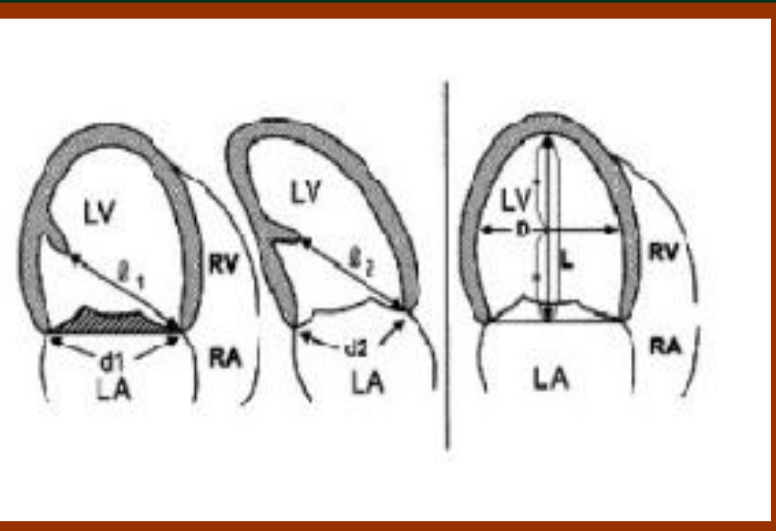
**Follow-up was a mean of 35.8 months.**

**Significant ( $\geq 2+$  MR), recurrent MR in 29% of patients.**

**“A surprise finding in this series was the incidence of recurrent mitral regurgitation...the overall rate of recurrent insufficiency was considered to be high.”**

**Conclusion: Functional ischemic MR remains a difficult problem to treat, and has a poor long-term outcome. Ring annuloplasty for functional ischemic MR with coronary artery disease achieves immediate valve competence. However, a significant number of patients develop recurrent MR at intermediate follow up.**

# Recurrent Ischemic Mitral Regurgitation After Annuloplasty



Matsunaga A, Tahta SA, Duran CMG: Failure of reduction annuloplasty for functional ischemic mitral regurgitation. J Heart Valve Dis 2004; 13: 390-8

*L'anuloplastica nonostante gli ottimi risultati immediati è seguita da una ricomparsa di IM significativa a tre anni nel 29 % dei casi*

***FATTORI PREDITTIVI DI INSUCCESSO (persistenza o precoce ricomparsa)***

- *altezza di coaptazione >10mm*
- *accentuata dislocazione laterale del mm. P.P*
- *accentuata sfericizzazione del VS*

## Left Ventricular Dysfunction

# Impact of Mitral Valve Annuloplasty on Mortality Risk in Patients With Mitral Regurgitation and Left Ventricular Systolic Dysfunction

Audrey H. Wu, MD, MPH,\* Keith D. Aaronson, MD, MS,\* Steven F. Bolling, MD, FACC,†  
Francis D. Pagani, MD, PhD, FACC,† Kathy Welch, MS, MPH,‡ Todd M. Koelling, MD, FACC\*

*Ann Arbor, Michigan*

**CONCLUSIONS** In this analysis, there is no clearly demonstrable mortality benefit conferred by MVA for significant MR with severe LV dysfunction. A prospective randomized control trial is warranted for further study of mortality with MVA in this population. (J Am Coll Cardiol 2005;45:381-7) © 2005 by the American College of Cardiology Foundation

## *Isolated CABG correct FMR?*

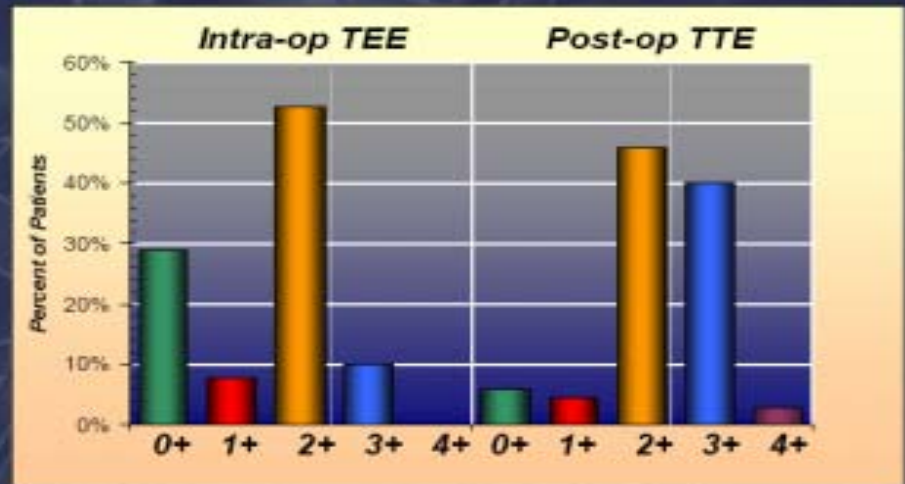
# Does Coronary Artery Bypass Grafting Alone Correct Moderate Ischemic Mitral Regurgitation?

Lishan Aklog, MD; Farzan Filsoufi, MD; Kathryn Q. Flores, MD; Raymond H. Chen, MD; Lawrence H. Cohn, MD; Nadia S. Nathan, MD; John G. Byrne, MD; David H. Adams, MD

*CABG alone for moderate IMR leaves many pts with significant (3 to 4+) residual MR.*

*Intra-op TEE may underestimate the severity of IMR.*

## CABG alone for 3+ Ischemic MR

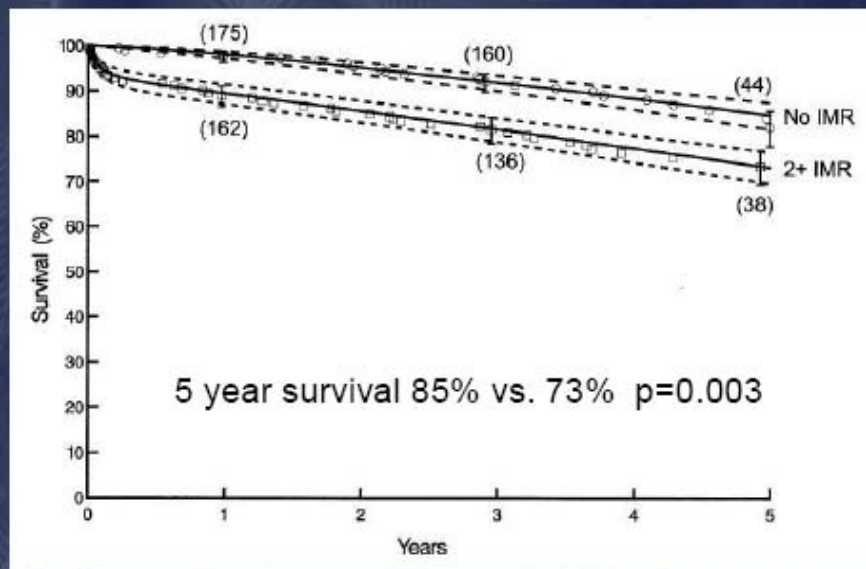


*Aklog L, et al. Circulation 2001;104:1-68*



# CABG e PCI risolvono MR?

## CABG alone for 2+ Ischemic MR



n=467 propensity matched patients

Lam et al. Ann Thorac Surg 2005;79:462

# CABG e PCI risolvono MR?

## Impact of Mitral Regurgitation on Long-Term Survival after Percutaneous Coronary Intervention

Ellis et al, The American Journal of Cardiology 2002

*Conclusion:...the presence of MR in pts undergoing PCI significantly and rather dramatically decreases survival over 3 yrs in a graded fashion especially for pts with EF < 40%*

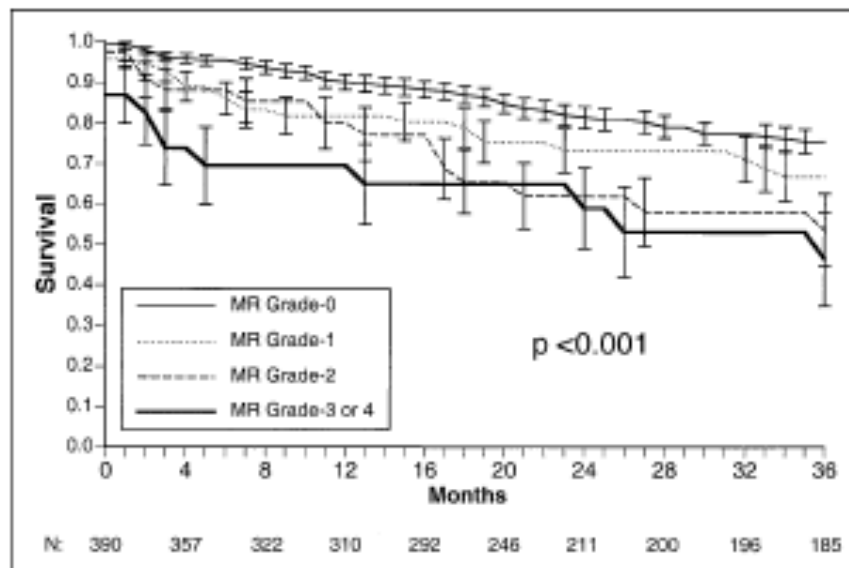


FIGURE 2. Kaplan-Meier survival curves for patients with LV ejection fraction < 40%, characterized by degrees of MR.

# *Surgical Treatment of the Ischemic Mitral Valve*

*Scopo: Determinare il miglior trattamento per IMI moderata al momento della rivascolarizzazione coronarica.*

## *Conclusioni:*

*La disfunzione tipo IIIb, secondo la classificazione di Carpentier, è la norma per IMI e una anuloplastica riduttiva può aumentare la coaptazione tra i lembi.*

*La mortalità dell'intervento combinato è diminuita dal 14% al 4% nell'ultima decade.*

*Quando rimane una IM residua significativa, espone il paziente al bisogno potenziale di un reintervento di chirurgia mitralica che comporta rischi operatori significativi.*

*“ Noi crediamo che tutti i pazienti con IMR moderato dovrebbero ricevere un'anuloplastica con anello rimodellante completo.”*

# How to improve results of annuloplasty?

## Paradoxical Decrease in IMR with PM dysfunction

If IMR results from a net imbalance of apically directed forces ( $>$  tethering  $<$  LV Contraction), the normal PM contraction should in principle increase apical Tethering and augment MR

If we add contractile dysfunction of the PMs, this fact can paradoxically diminish MR by allowing the leaflet to seat better and to close more effectively.

Tethering may be reduced by possible stretching of the ischemic PM towards the annulus by LV force transmitted through the leaflet and chords

**Conclusions**—PM contractile dysfunction can paradoxically decrease MR from inferobasal ischemia by reducing leaflet tethering to improve coaptation. This emphasizes the role of geometric factors in ischemic MR mechanism and potential therapy. (*Circulation*. 2001;104:1952-1957.)

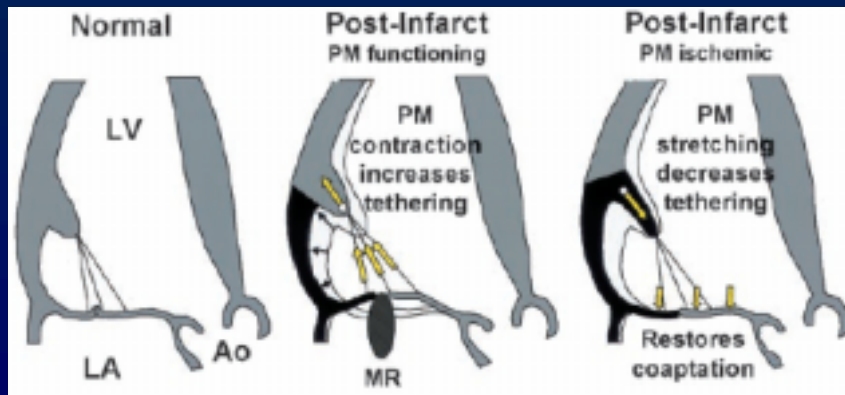


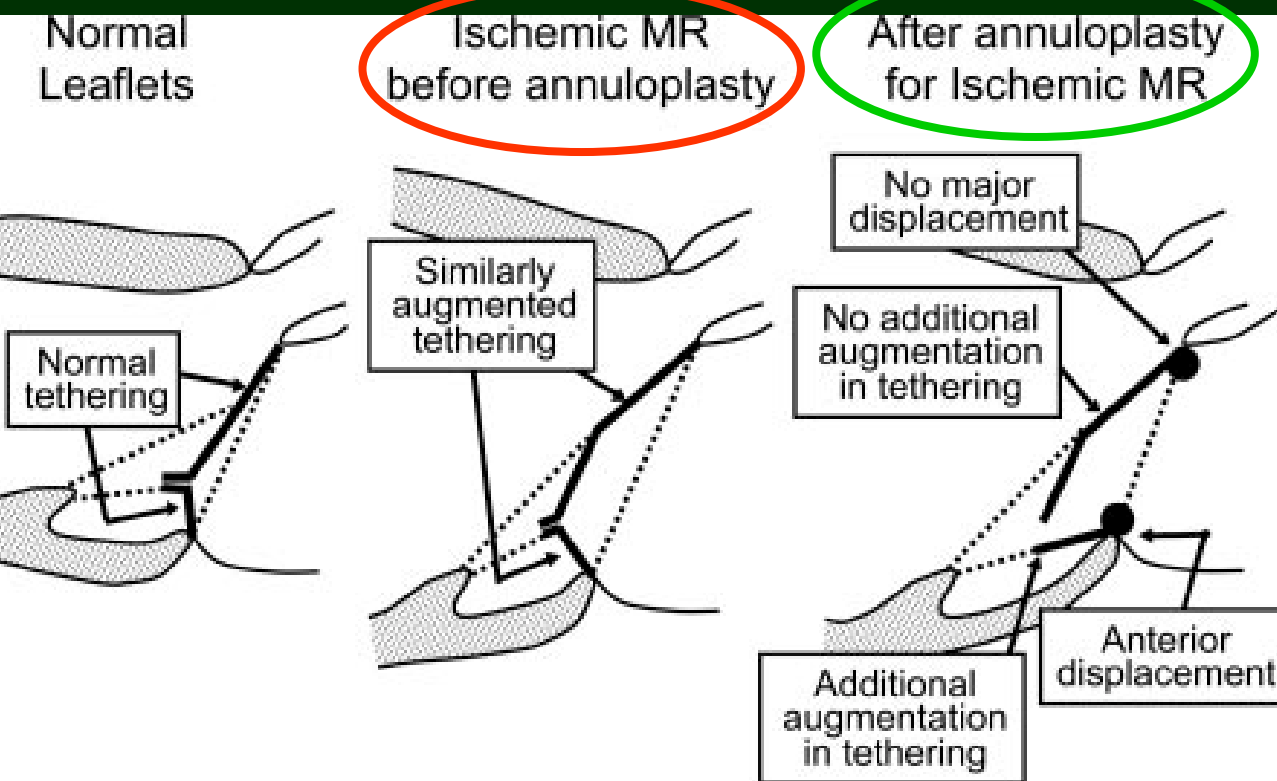
Figure 1. Hypothesis: How PM dysfunction can decrease ischemic MR. Left, Baseline configuration of LV with normal mitral leaflet closure. Middle, Inferobasal infarction with PM still functioning, causing MR by outward distortion of the inferior base. Right, Extension of ischemic zone to include PM can paradoxically diminish MR by reducing tethering so that leaflets can seat better at annular level. Ao indicates aorta.

*Mechanism of Recurrent/Persistent Ischemic/Functional  
Mitral Regurgitation in the Chronic Phase After  
Surgical Annuloplasty  
Importance of Augmented Posterior Leaflet Tethering*

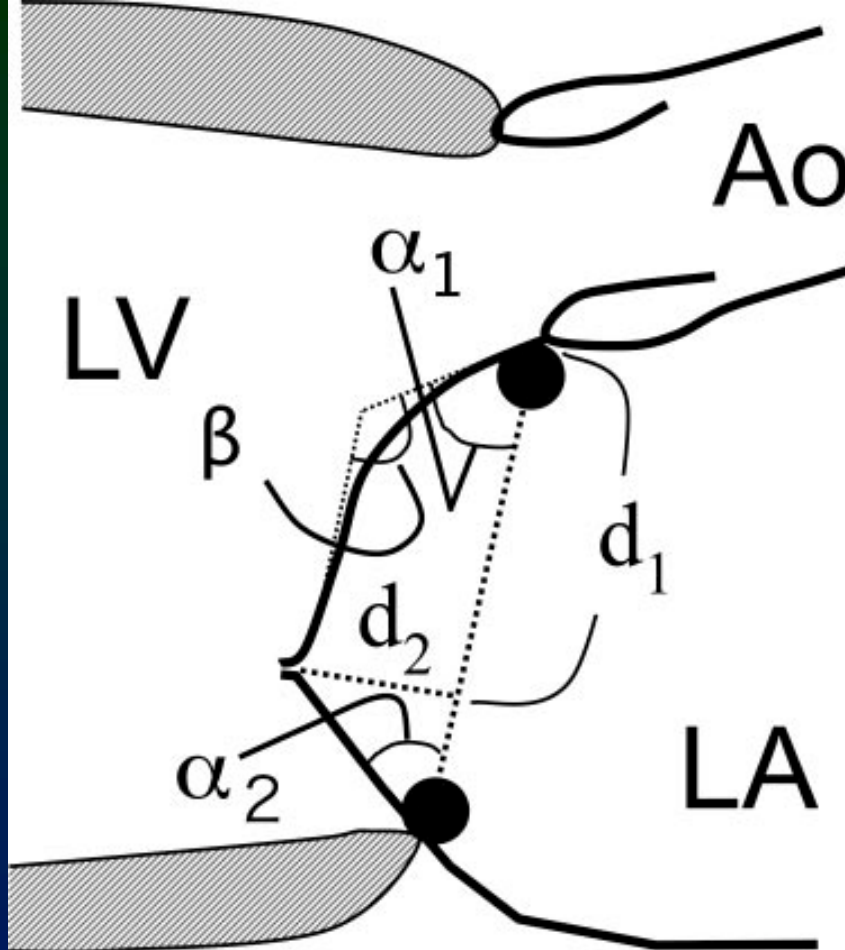
*Eiji Kuwahara, MD; Robert A. Levine, MD; Ryuzo Sakata, MD; Chuwa Tei, MD;  
et al.*

**Conclusions:** Whereas both leaflets tethering is related to preoperative ischemic MR, both leaflets tethering but with predominant contribution from augmented and progressive PML tethering is related to recurrent/persistent ischemic/functional MR late after surgical annuloplasty.

*(Circulation. 2006;114[suppl I]:I-529-I-534.)*

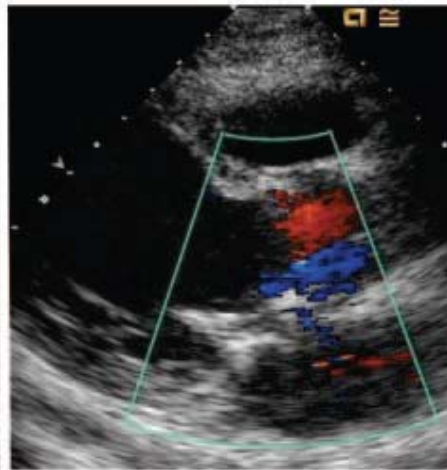
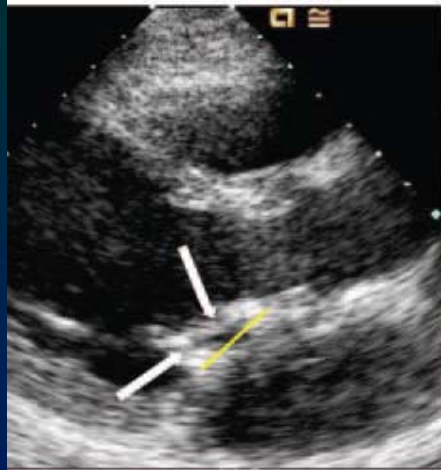


**Figure 1.** Potential mechanism of augmented tethering of the posterior mitral leaflet (PML) by surgical annuloplasty. Displacement of papillary muscles (PM) with left ventricular (LV) remodeling similarly increases tethering angles between anterior leaflet (AML) or PML and the line connecting mitral annuli (middle). Surgical annuloplasty may hoist posterior annulus anteriorly without displacing the anterior annulus fixed at the aortic root, which specifically augment PML tethering (right).

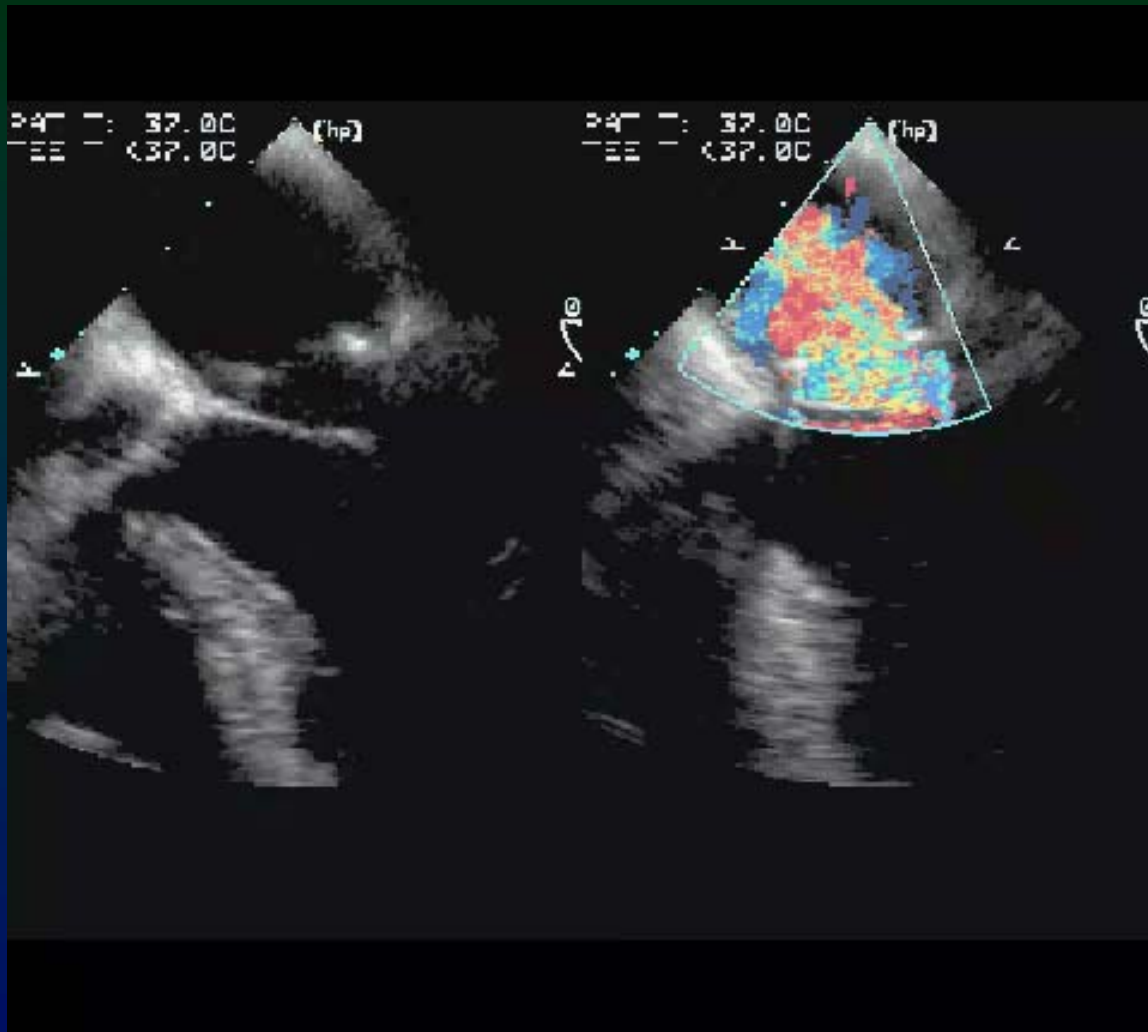


*Figure 2.* Mitral leaflet configurations in the parasternal long axis echocardiogram.  $d_1$ ,  $d_2$ ,  $\alpha_1$ ,  $\alpha_2$ , and  $\beta$  denote posterior and apical displacement of the coaptation, tethering of the anterior and posterior leaflet, and tethering of anterior leaflet from basal chordae, respectively.









IM ischemica: pre – post anuloplastica riduttiva

## *In summary:*

CABG alone does not completely correct MR

MV repair is now accepted to be superior to replacement in **most** pts

Undersized ring annuloplasty is commonly used to treat IMR

MV repair with undersized Flexible posterior band or ring and even symmetric remodelling rings leaves 10% - 30 % of pts with residual or recurrent IMR

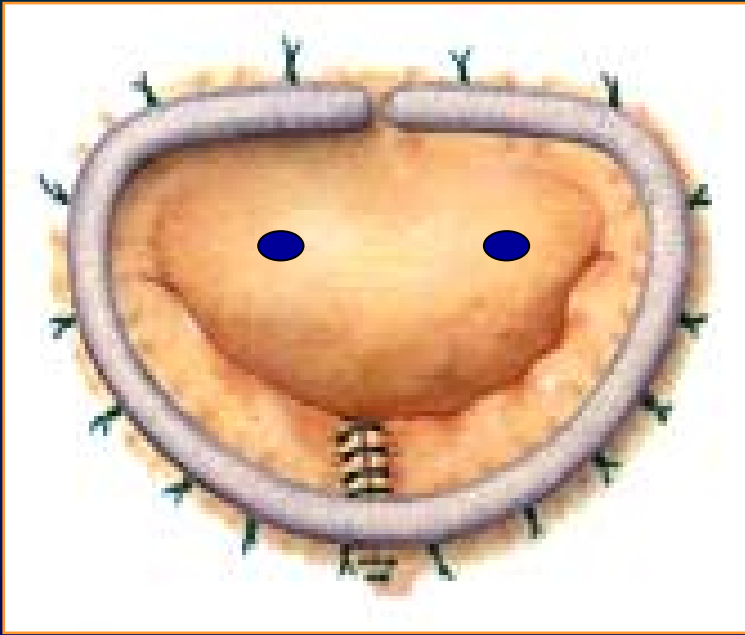
Recent clinical studies, **ie Kwan**, reported that the pattern of MV deformation from postero-medial to the antero-lateral commissura is asymmetrically in IMR

In pts with IMR P2 and P3 segments are often asymmetrically restricted and associated with asymmetrical annulus dilatation

# Conclusion

*Think repair first !*

*With a team approach*



*Grazie per l'attenzione*

