Echo-Doppler evaluation of left ventricular diastolic function

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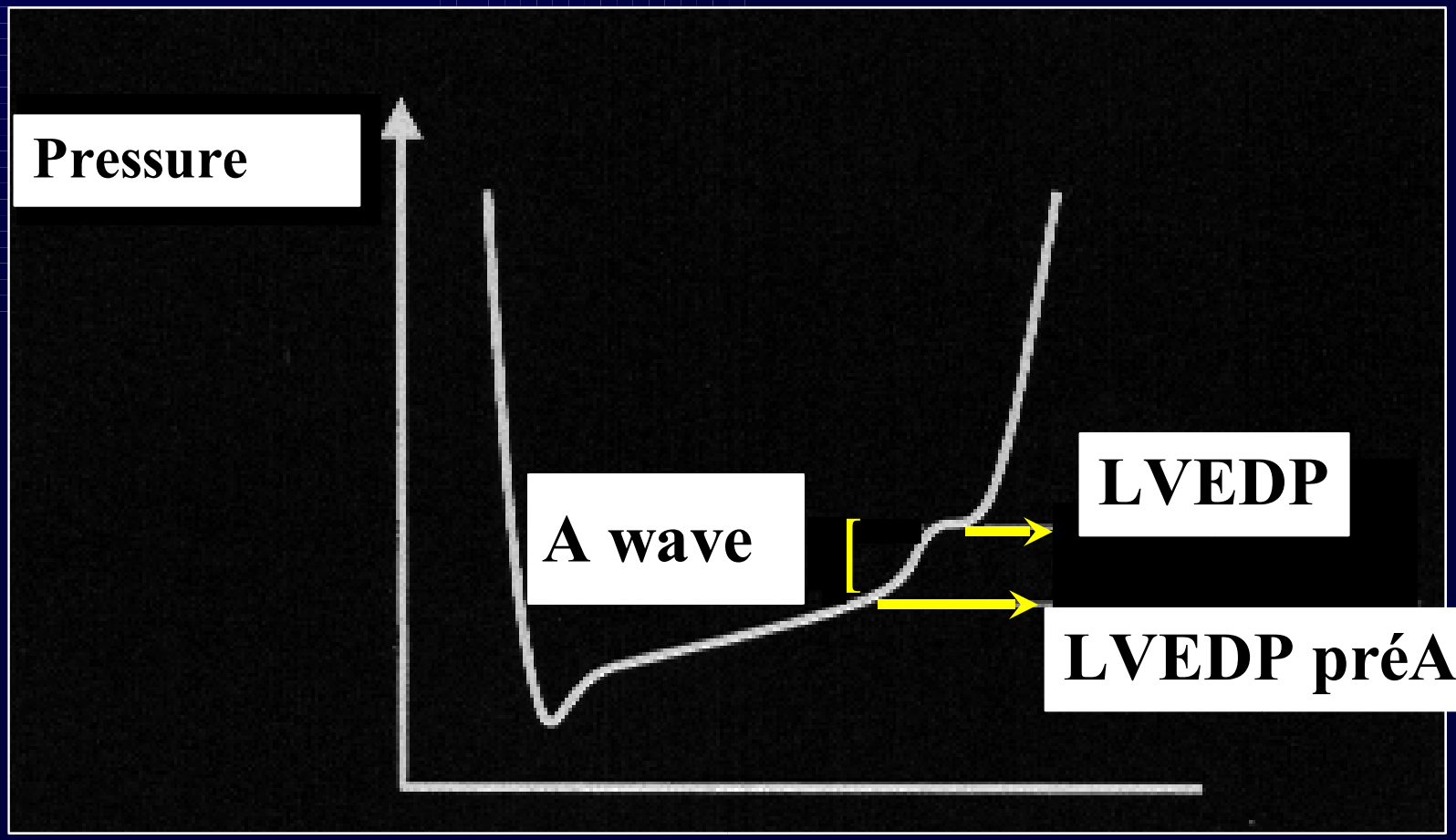
Amiens
France

Left ventricular pressure

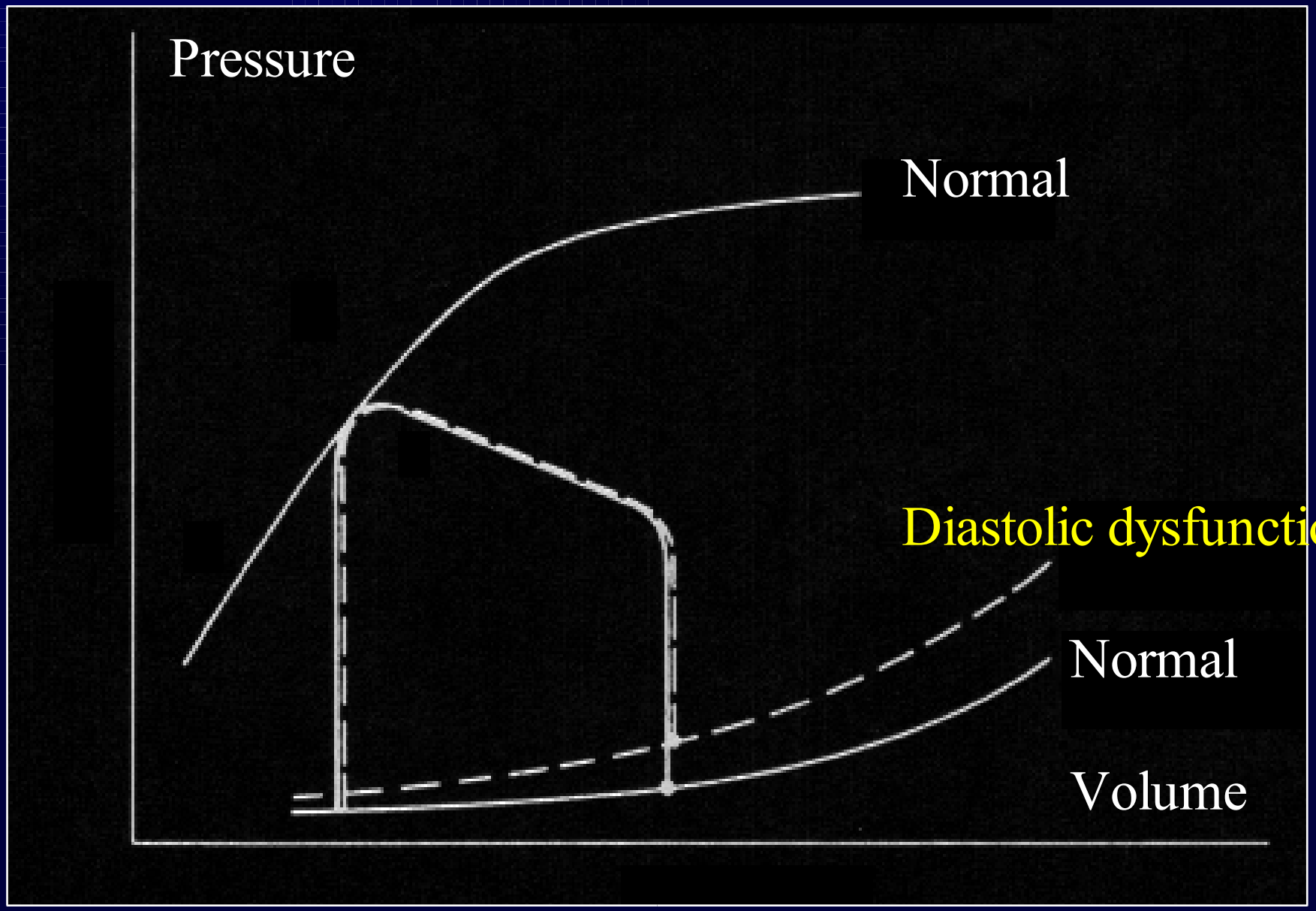


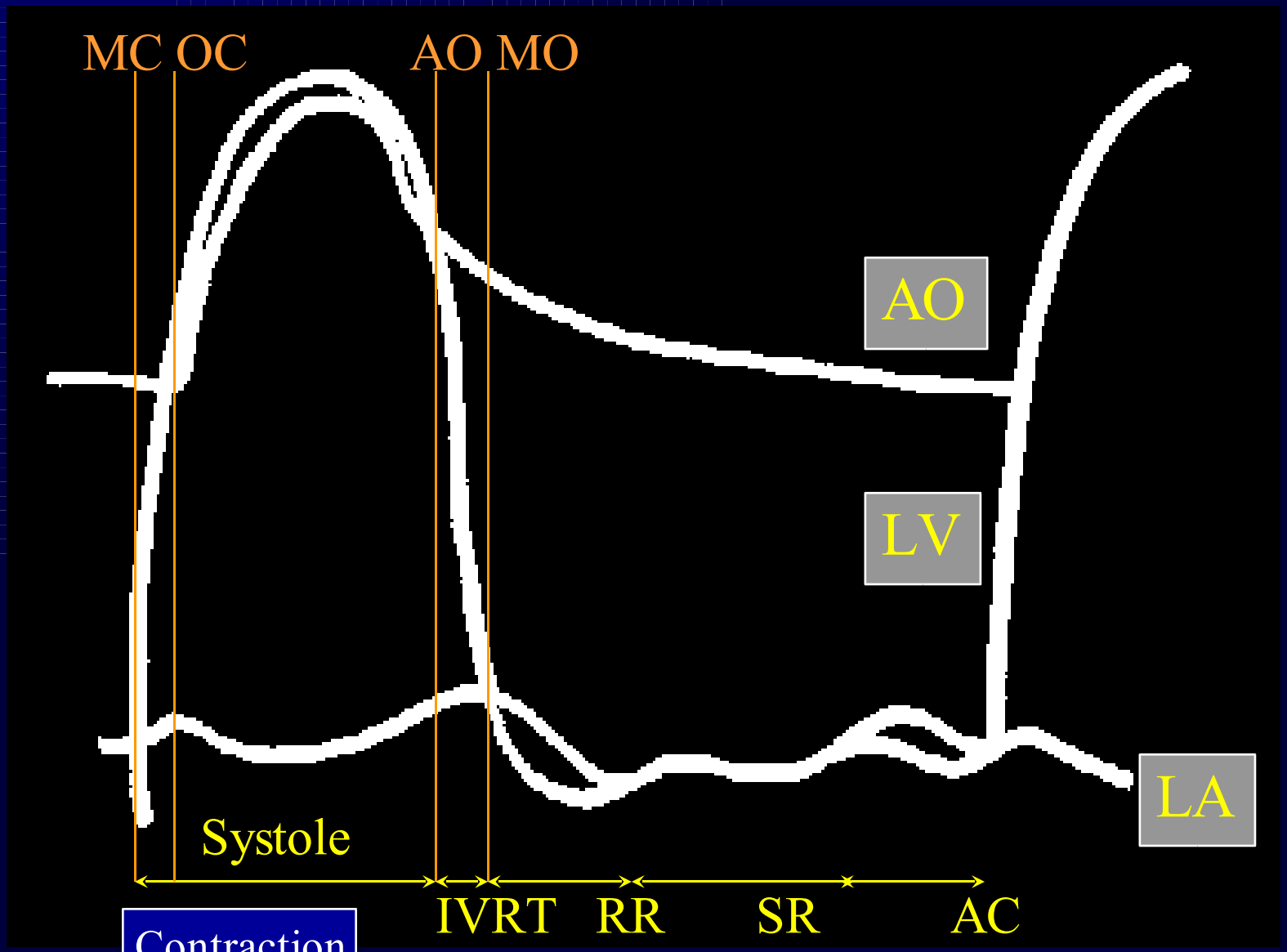
Congestive cardiac failure with preserved systolic function

- **50% of patients with congestive heart failure**

- Increased prevalence with
  - Age
  - Hypertension

Pathophysiology




MC OC
AO MO
AO
LV
LA
Systole
IVRT
RR
SR
AC
Contraction
Relaxation
Filling

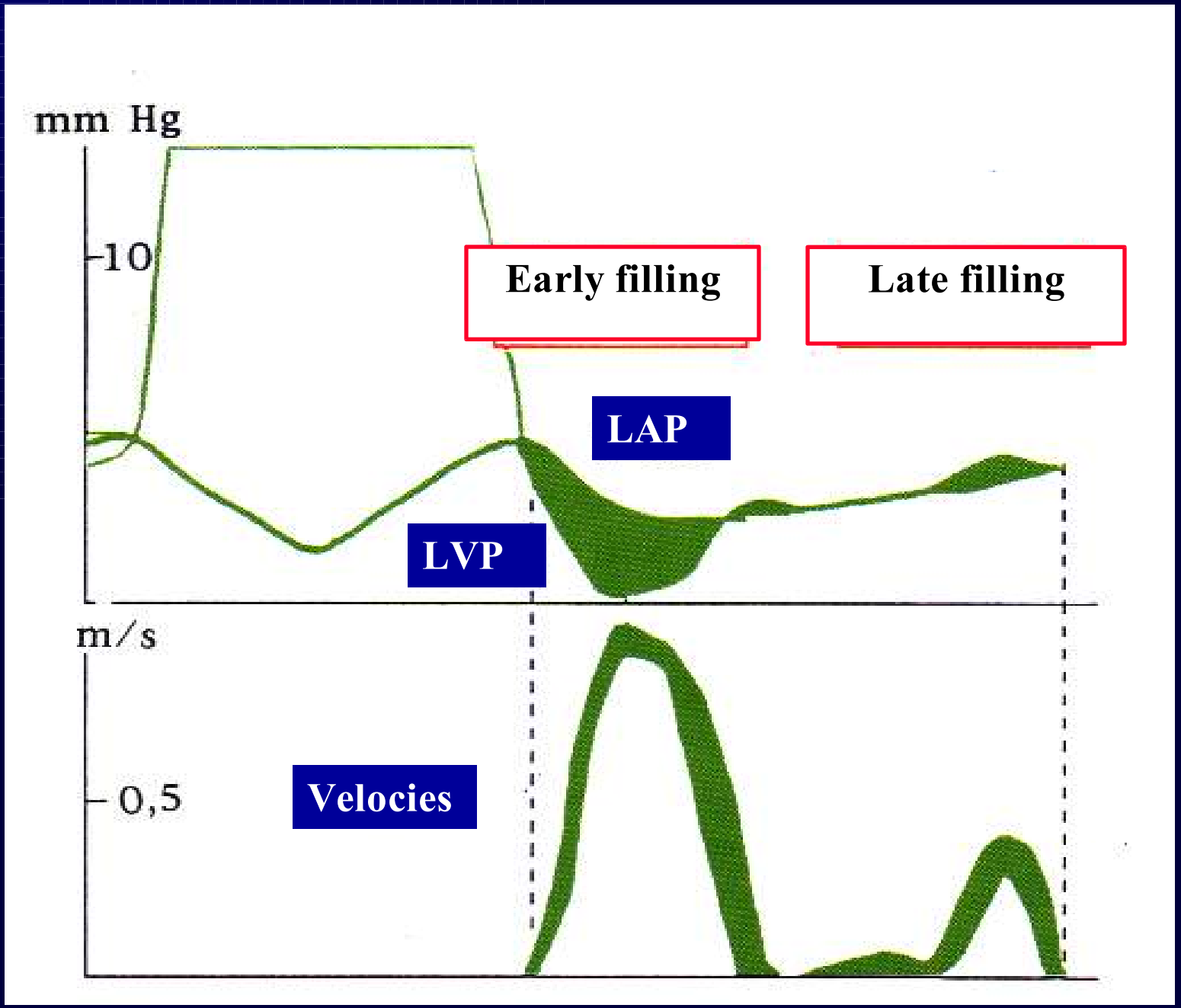
Diastolic cardiac dysfunction

- Impaired LV relaxation
- Impaired LV compliance
  - Hypertrophy
  - infiltration
  - Collagen

Tools

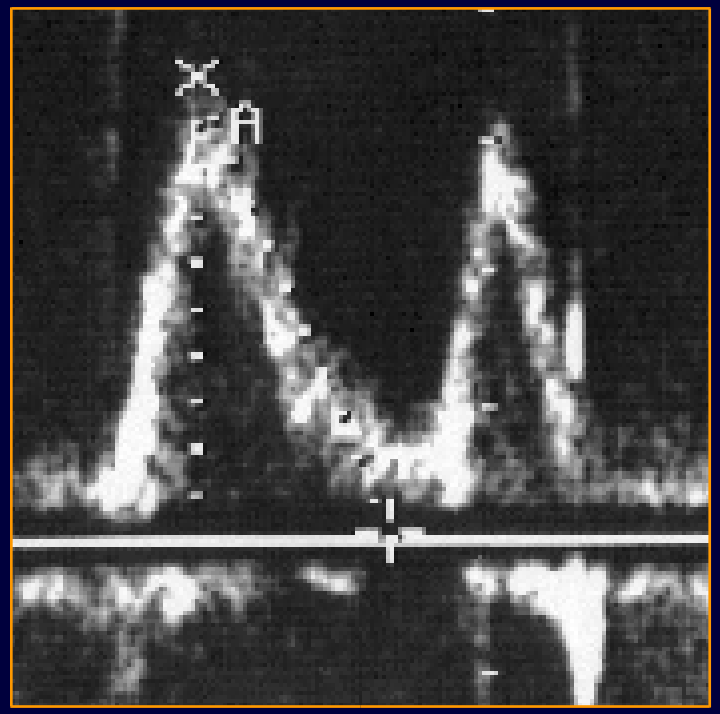
- Mitral flow
- Pulmonary venous flow
- Vp : left ventricular inflow propagation velocity using M-mode color Doppler imaging
- Ea : annulus displacement analysed using doppler tissue imaging (DTI)

I Mitral Flow

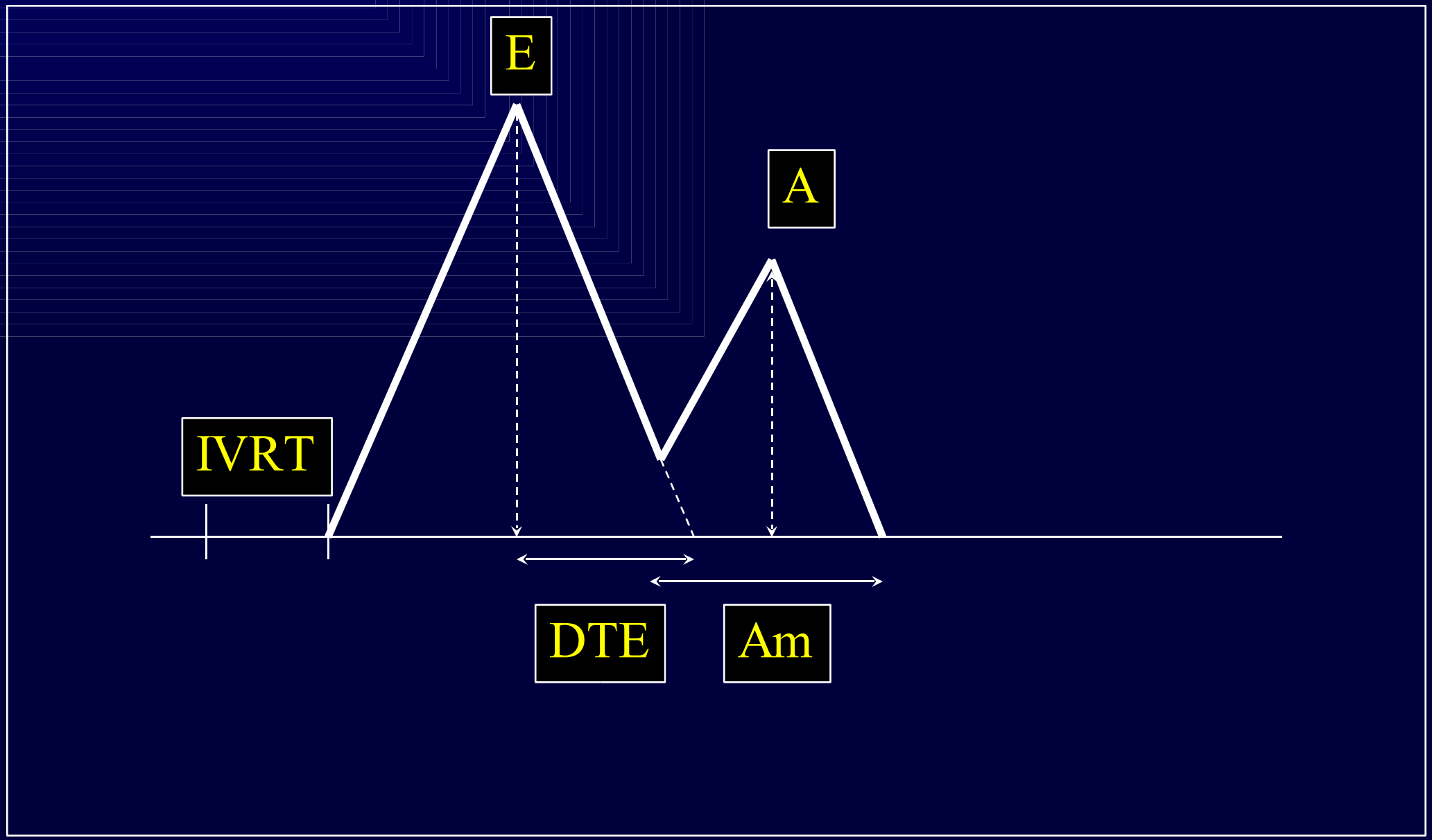

mm Hg
10
Early filling
Late filling
LAP
LVP
m/s
0,5
Velocies

Mitral flow : how to record ?

- Pulsed Doppler
- Correct Alignement
- Small window
- At the tip of mitral valve
- Visible opening sound
- Settings et filters
- 100 mm/s
- Average of 3 measurements



Mitral Flow : which measurement ?



Mitral Flow : normal values

(Appleton et al, J Am Coll Cardiol 1988 ; 12 : 426-40)

- **Isovolumic relaxation time**
  - **avant 40 ans : 69 ± 12ms**
  - **après 40 ans : 76 ± 13ms**

- **Maximal velocity of E : 86 ± 13 cm/s**
- **Maximal velocity of A : 56 ± 13 cm/s**
- **E/A : 1.6 ± 0.4**

- **Deceleration time of E : 199 ± 32 ms**

Normales:
- **E/A = 1 - 2**
- **TDE = 150-220 ms**
- **TRIV = 60 - 100 ms**

Factors influencing mitral flow

- Age
- Heart rate
- LV relaxation+++
- LV compliance+++
- Load conditions+++
- Mitral regurgitation or stenosis

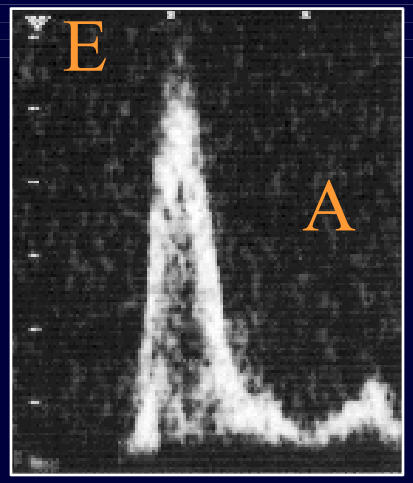
Mitral flow and age

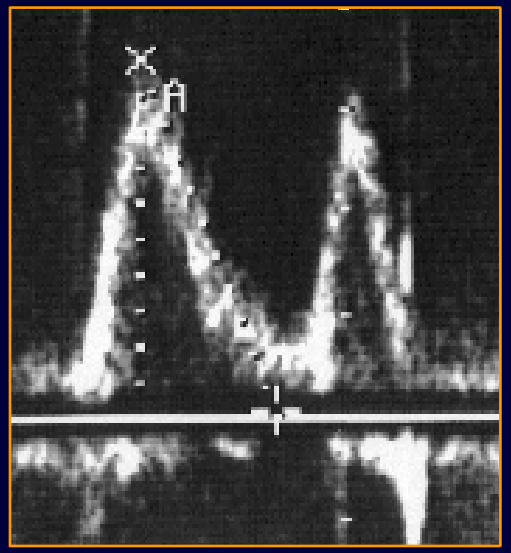
- Young subject
  ↗ E, ↘ A, ↗ E/A
  ↘ TDE

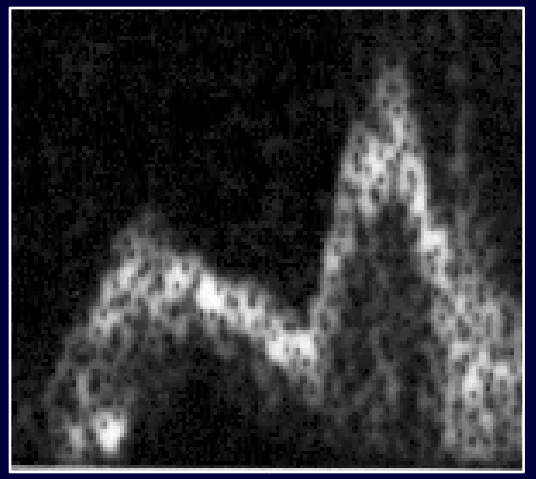
E/A < 1 in 85% of subjects > 70 ans
(Sagie et al. JASE 1993)

- Middle age subject

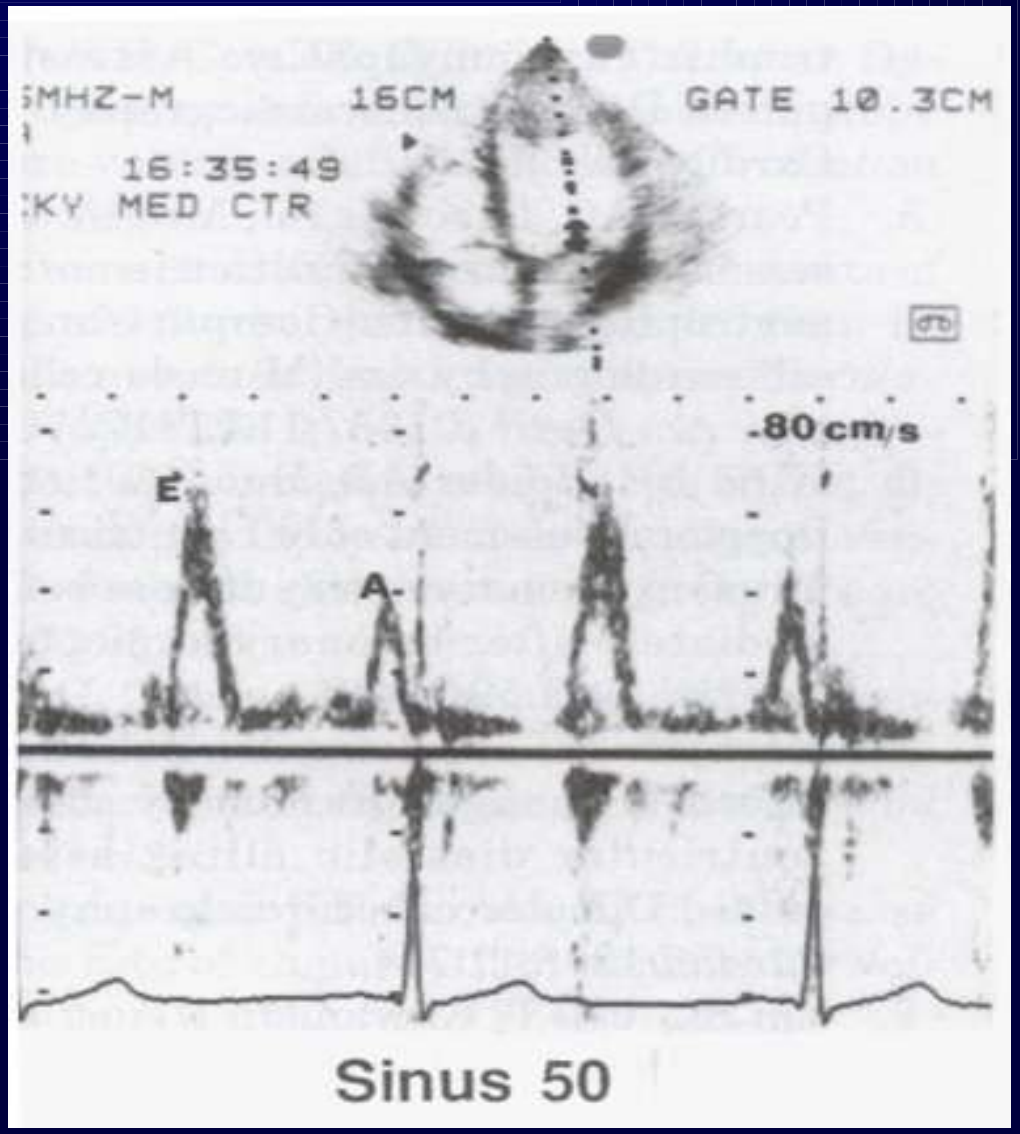
Aged subject



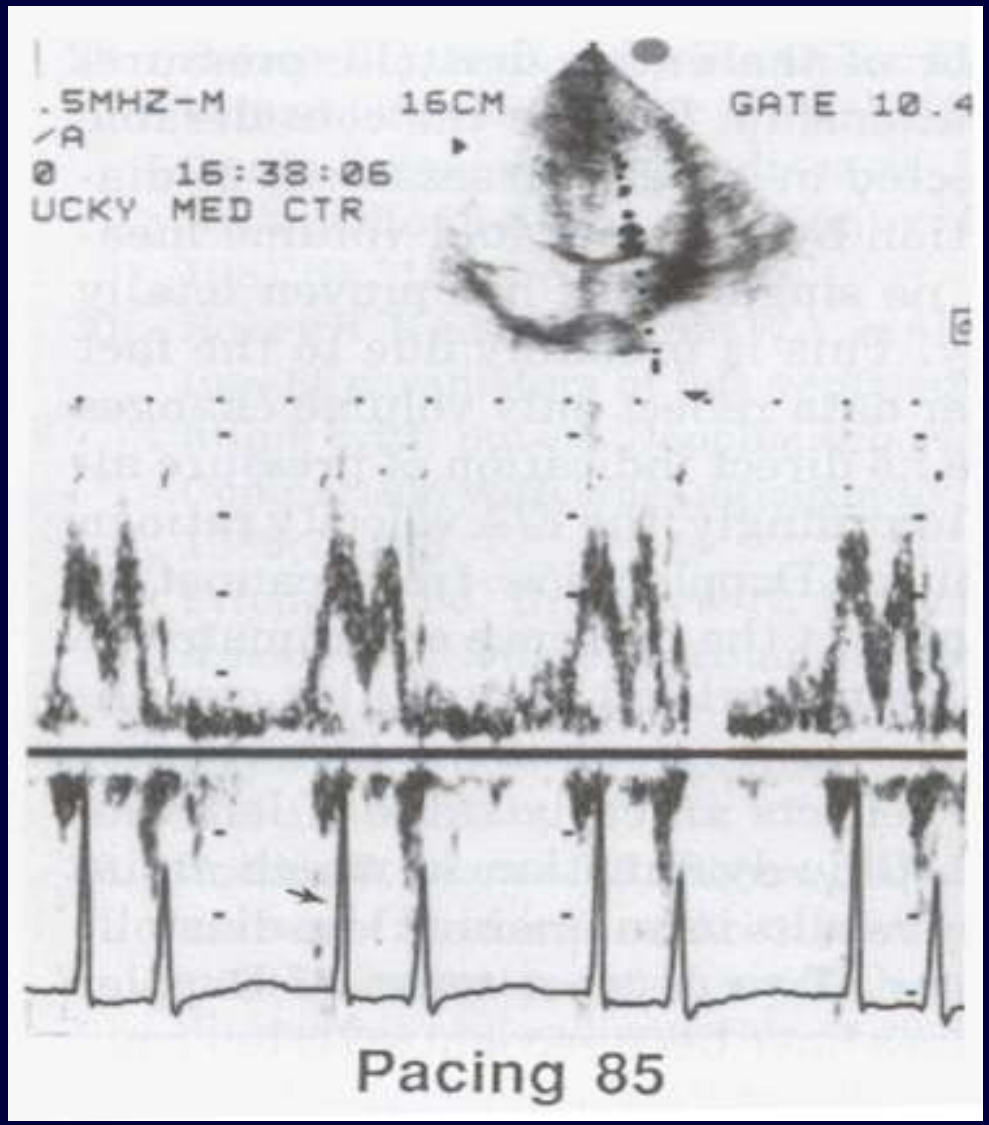




Heart Rate

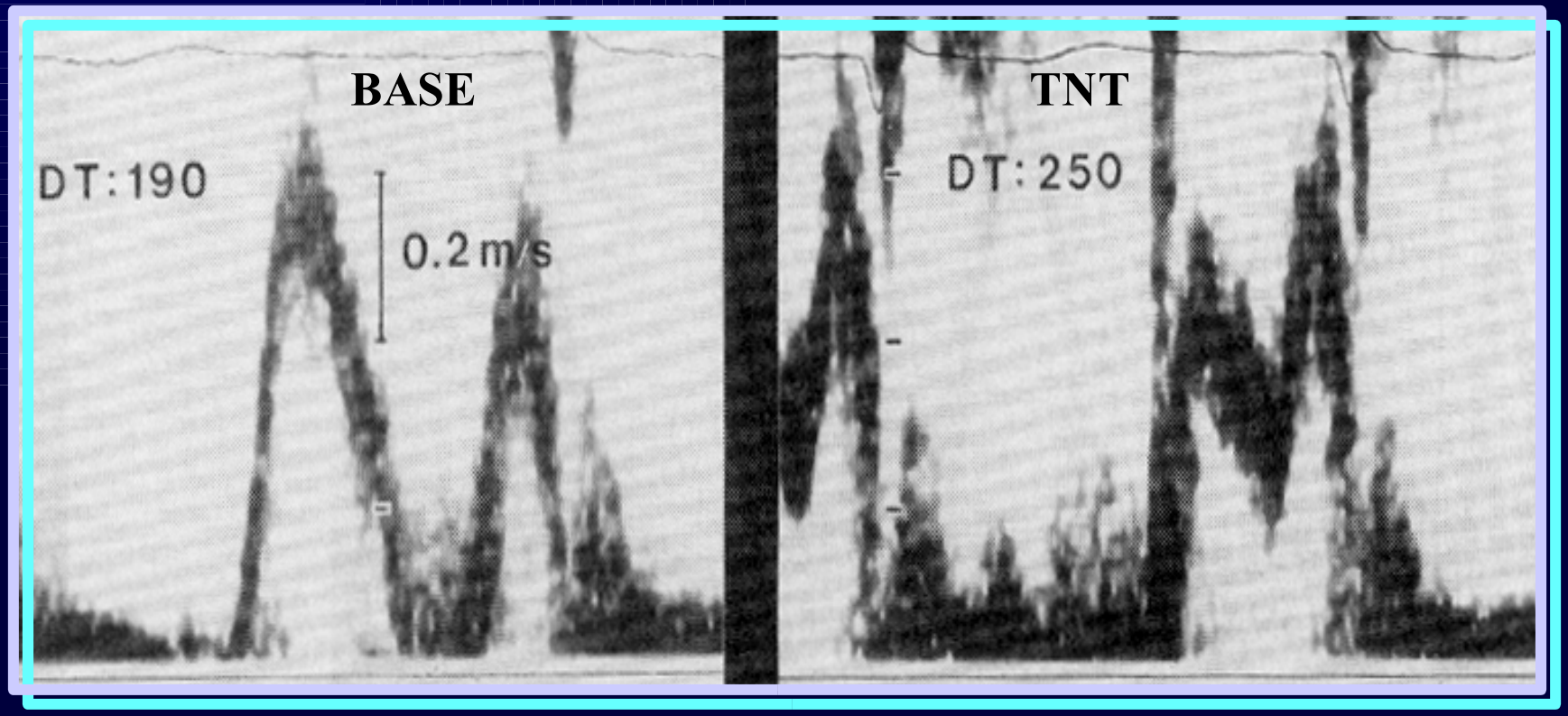


Sinus 50



Pacing 85

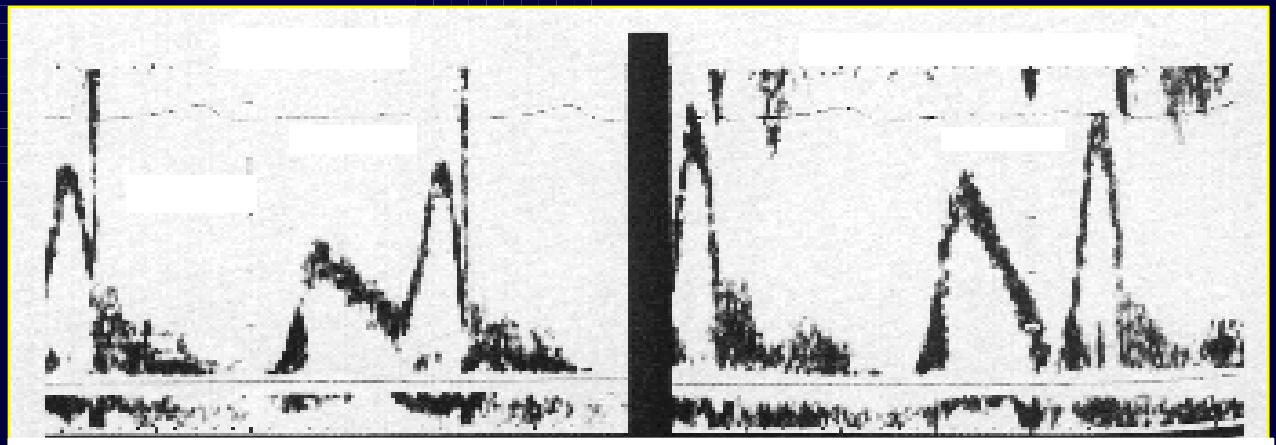
Decreased preload



SOHN, JACC 1997

Mitral Flow
Effect of preload modification

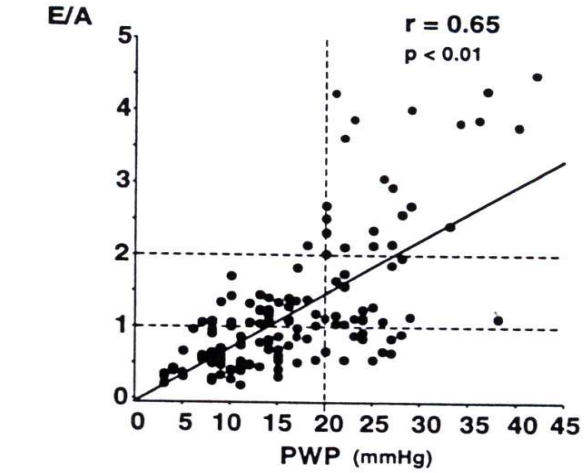
Basal | **Fluid challenge**

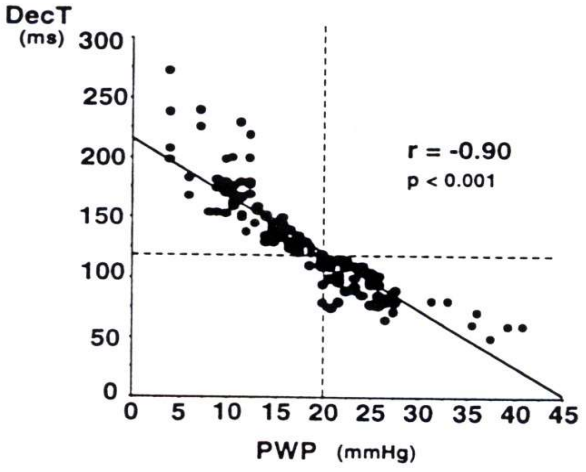


Mitral flow

LVDP

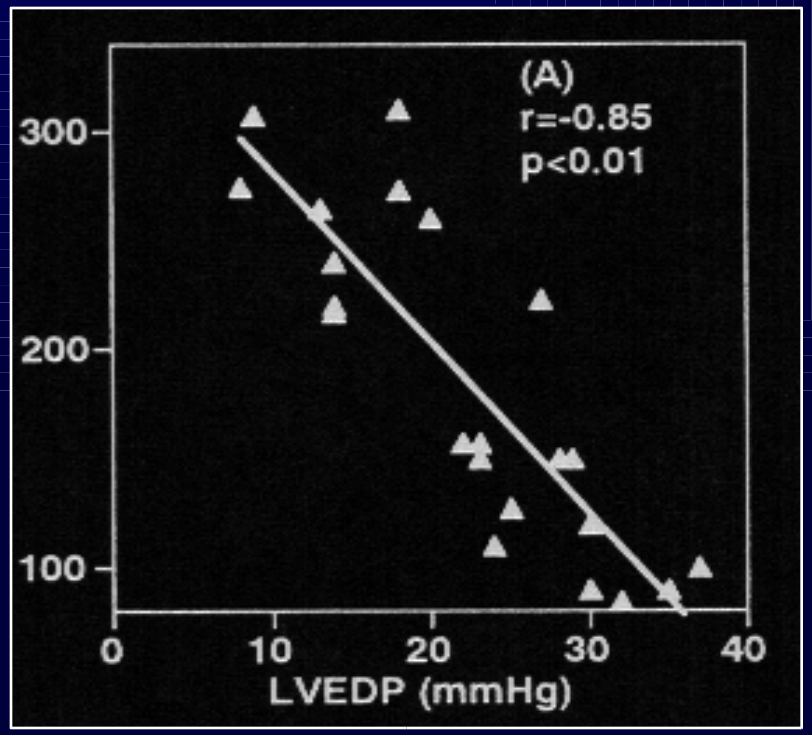
JACC 1994 ; 23 : 1630

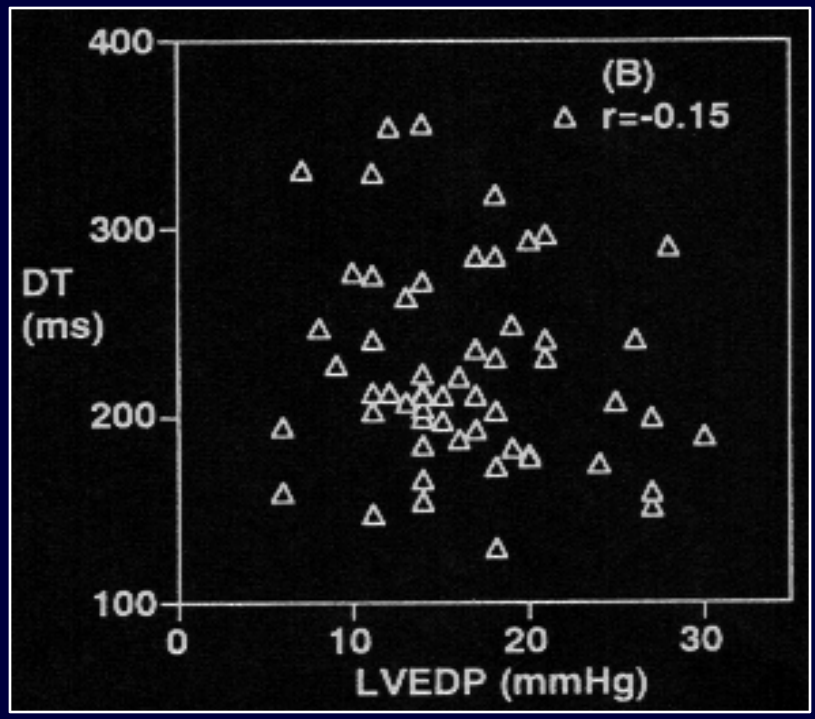




Correlation DTE and LVEDP

(Yamamoto et al. JACC 1997;30:1819-26)



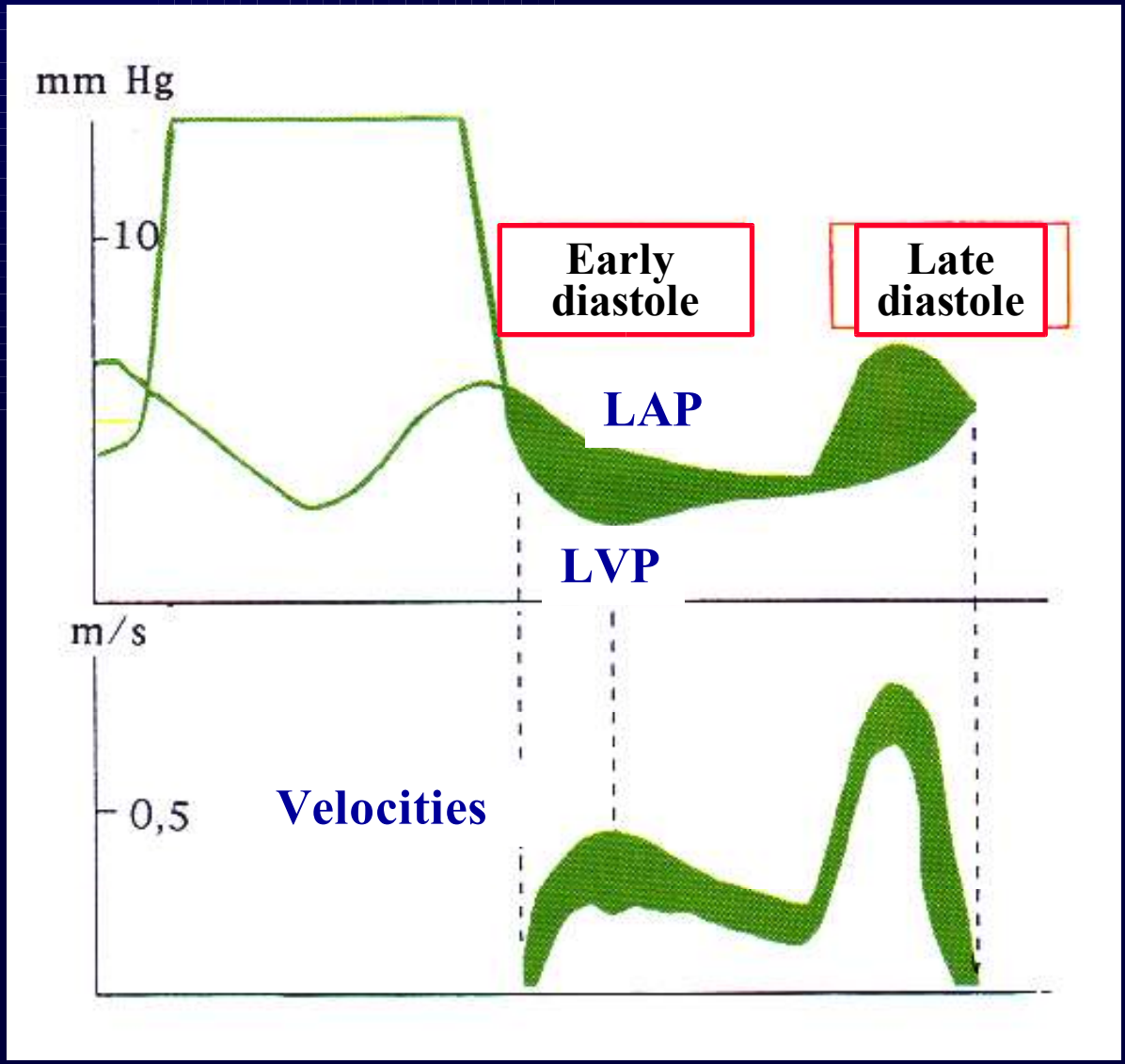


EF < 50% : r = - 0,85

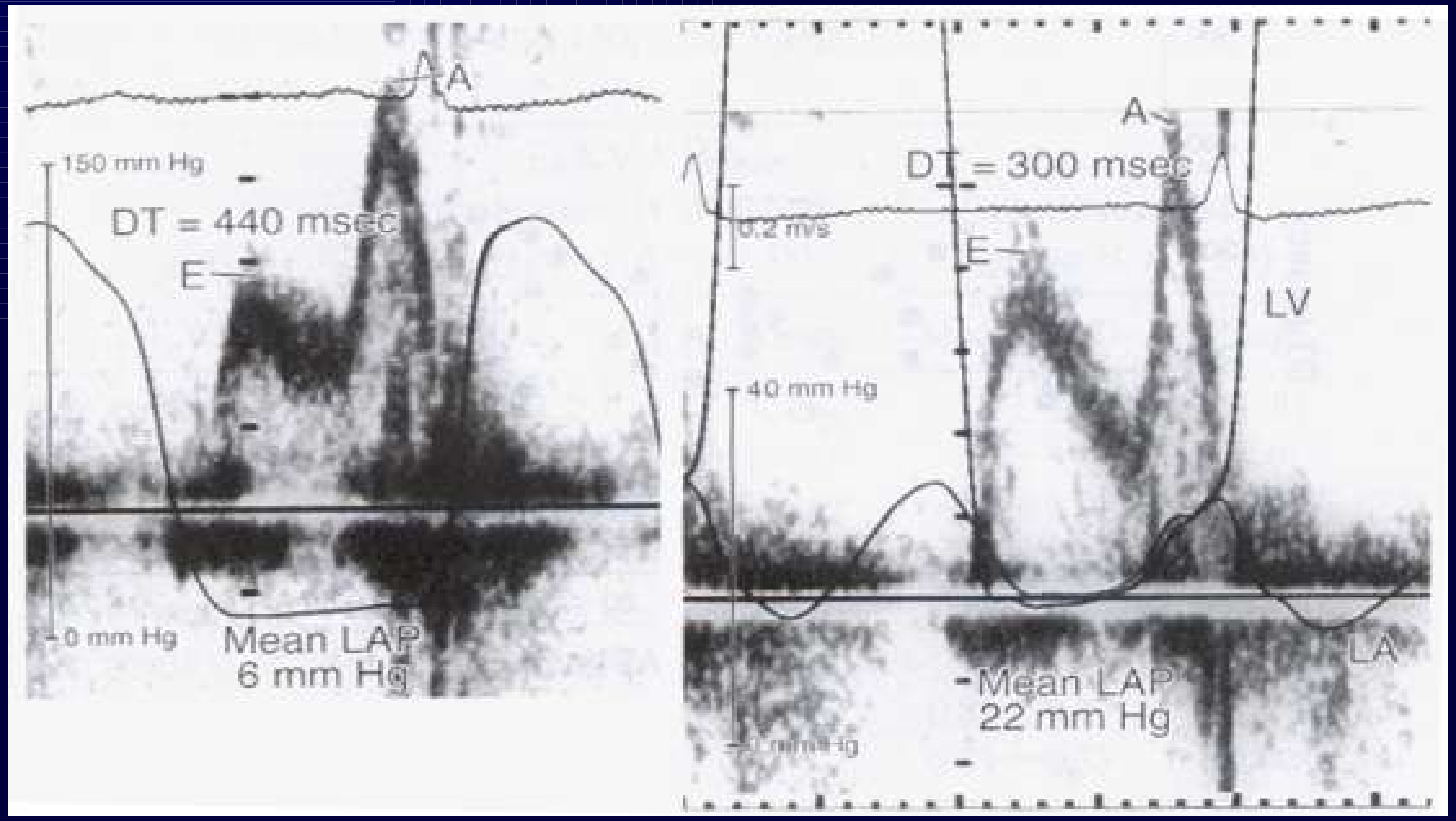
EF > 50% : r = - 0,15

DTE ≤ 150 ms et LV dysfunction : PTDVG ≥ 15 - 20 mmHg

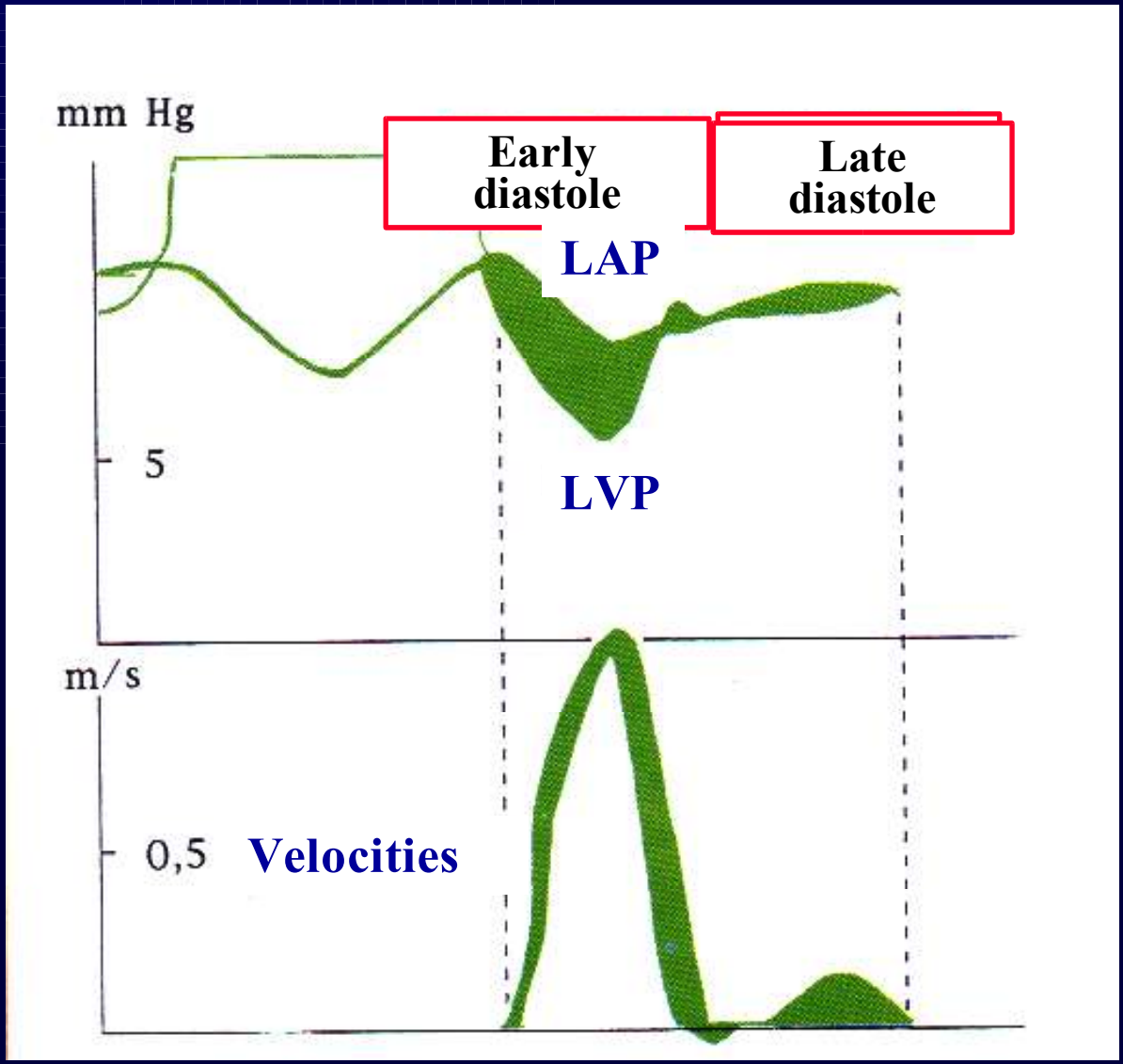
Type I of Appleton
relaxation impairement



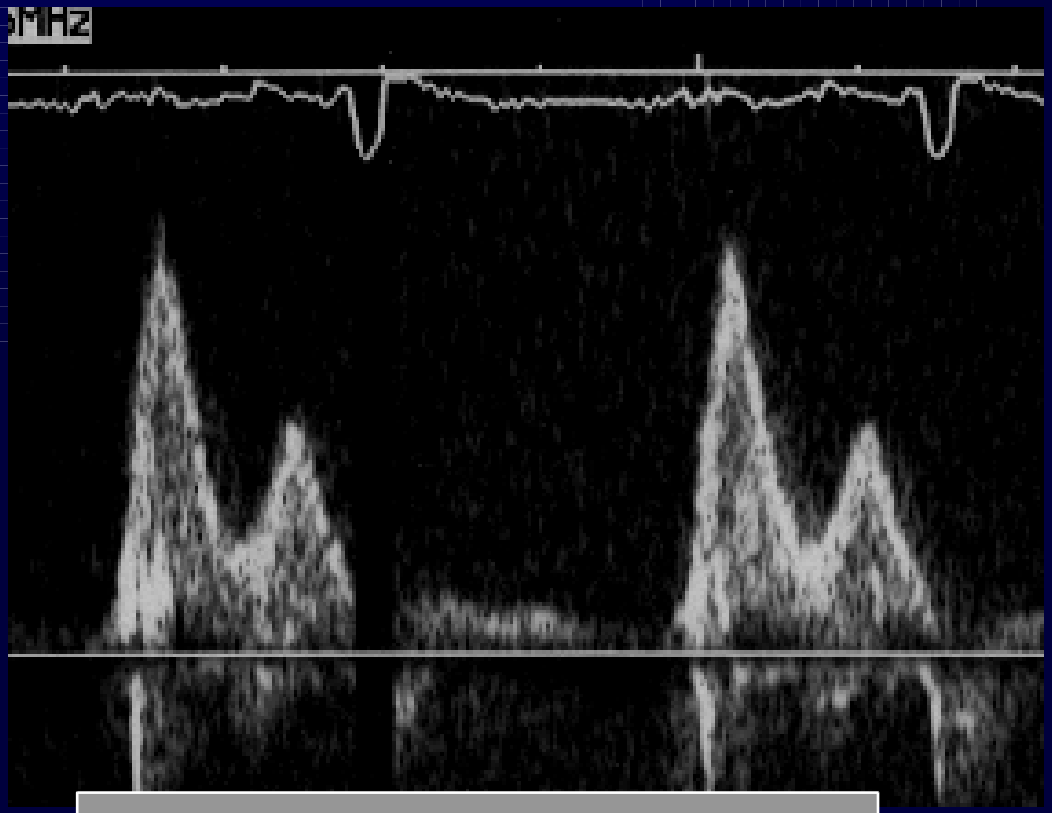
HCM with normal EF



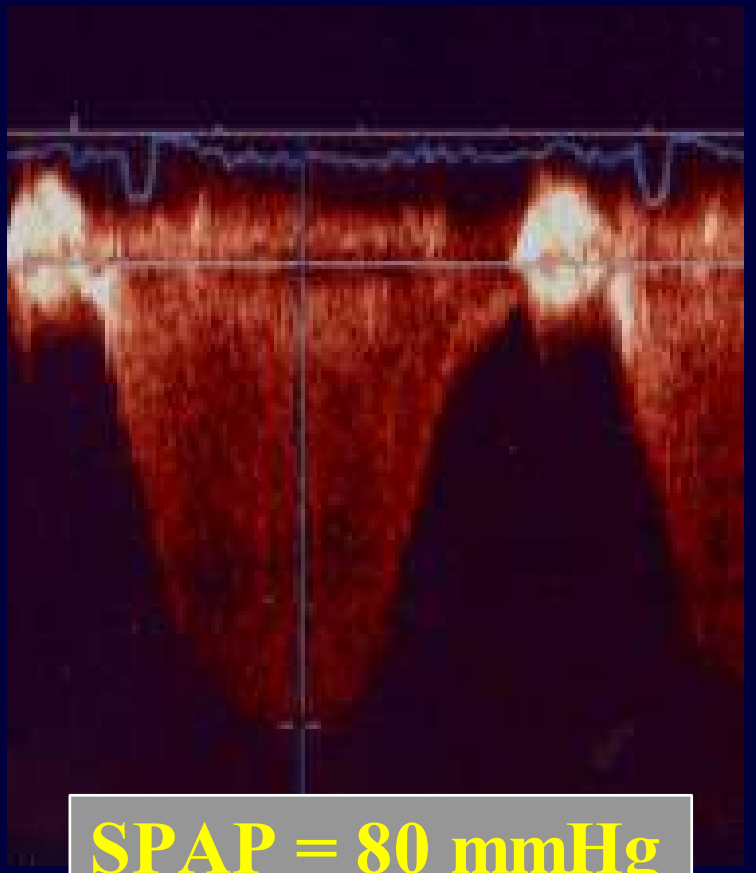
Flux Mitral Type II de Appleton



Compliance impairement (restrictive profile)
Anterior infarction - FE = 30%

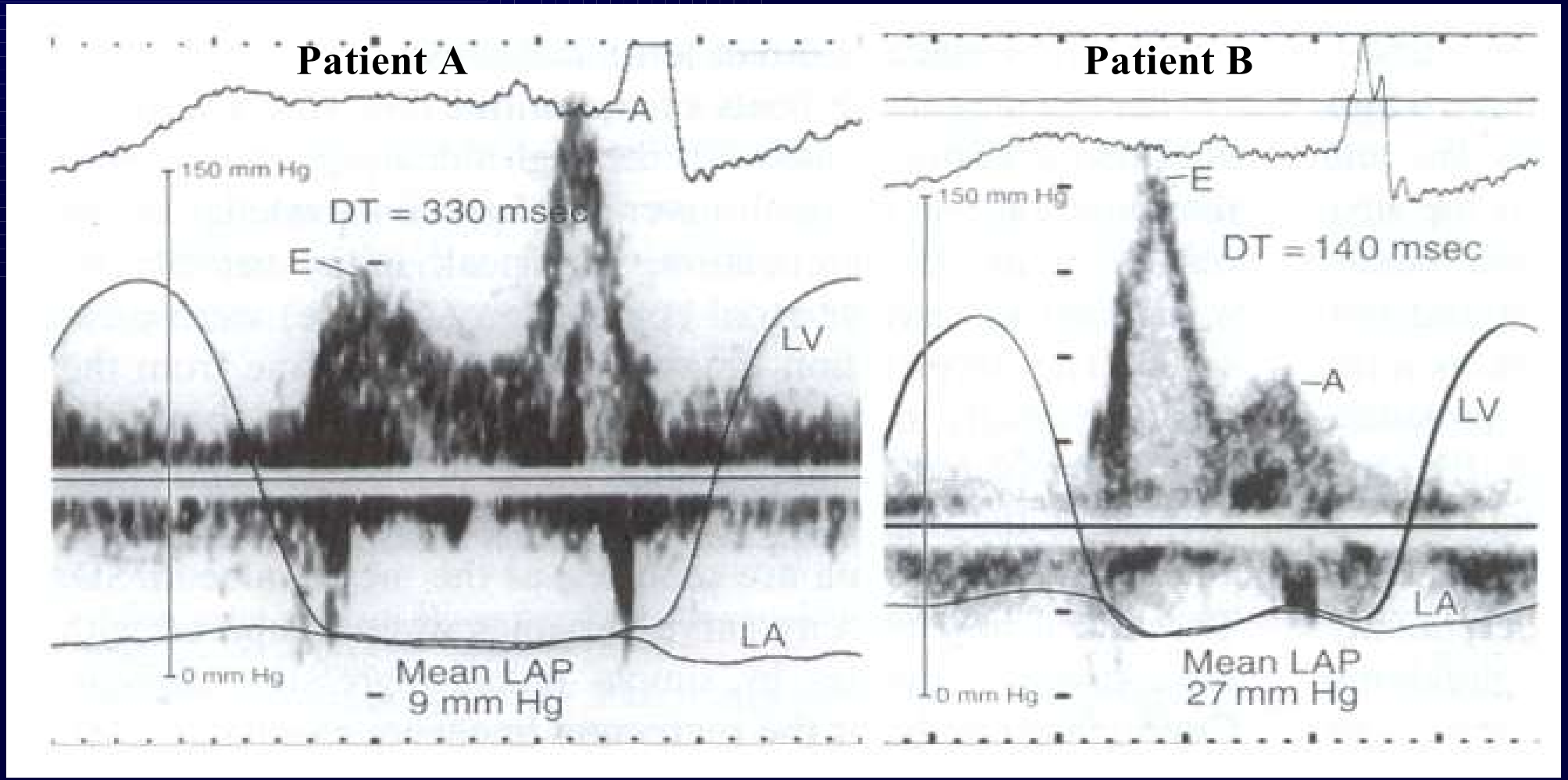


E/A = 2 ; DTE = 100 ms

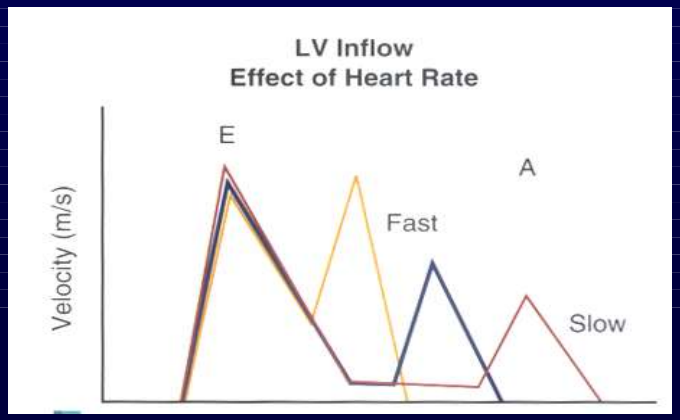


SPAP = 80 mmHg

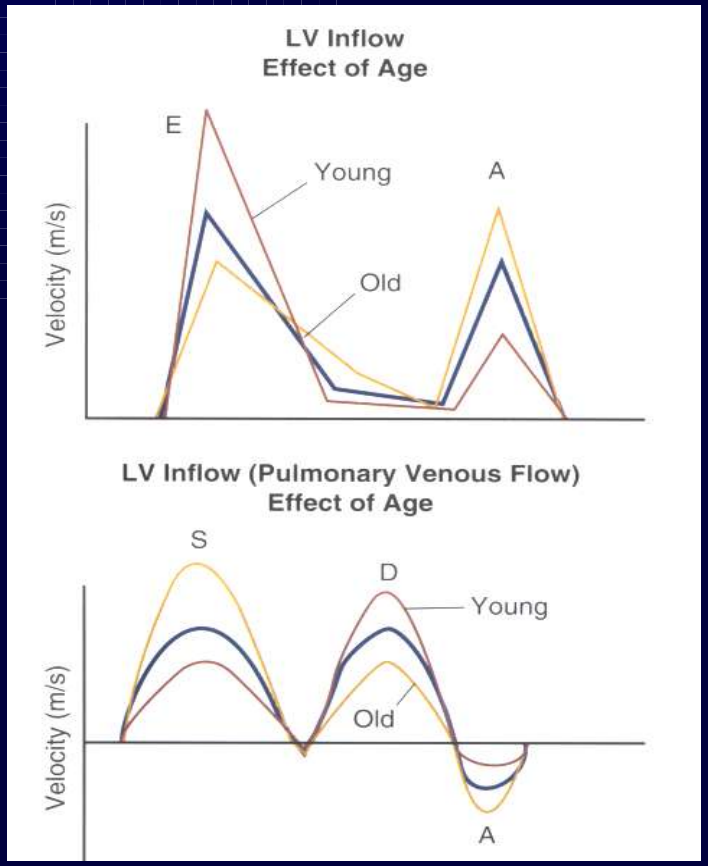
Ejection fraction = 30%



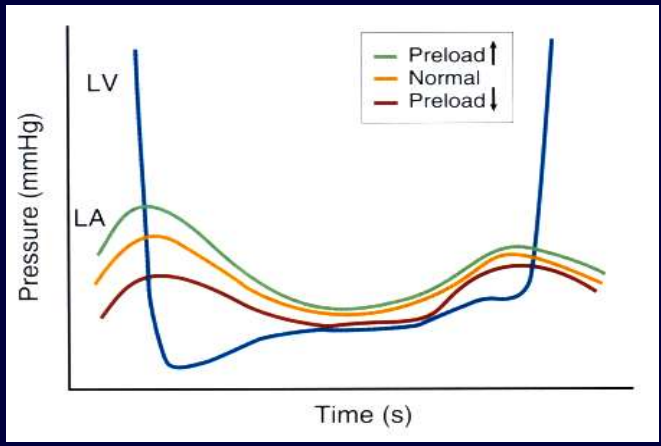
Heart Rate

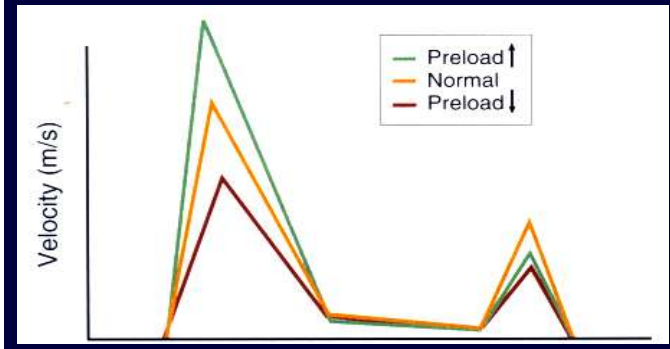


Age



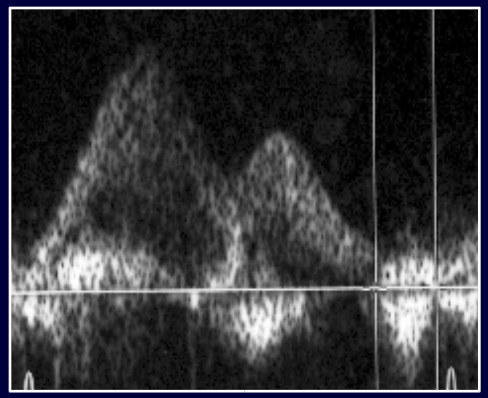
Preload





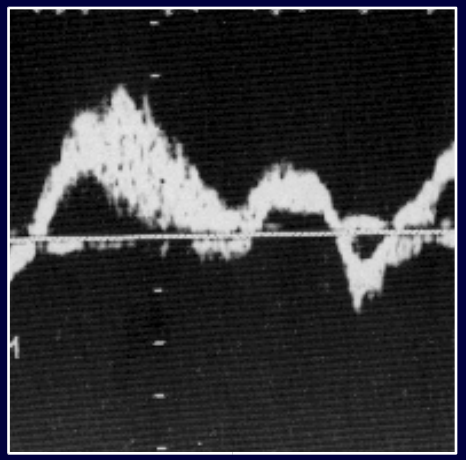
II Pulmonary venous flow

Pulmonary venous flow : how to record ?



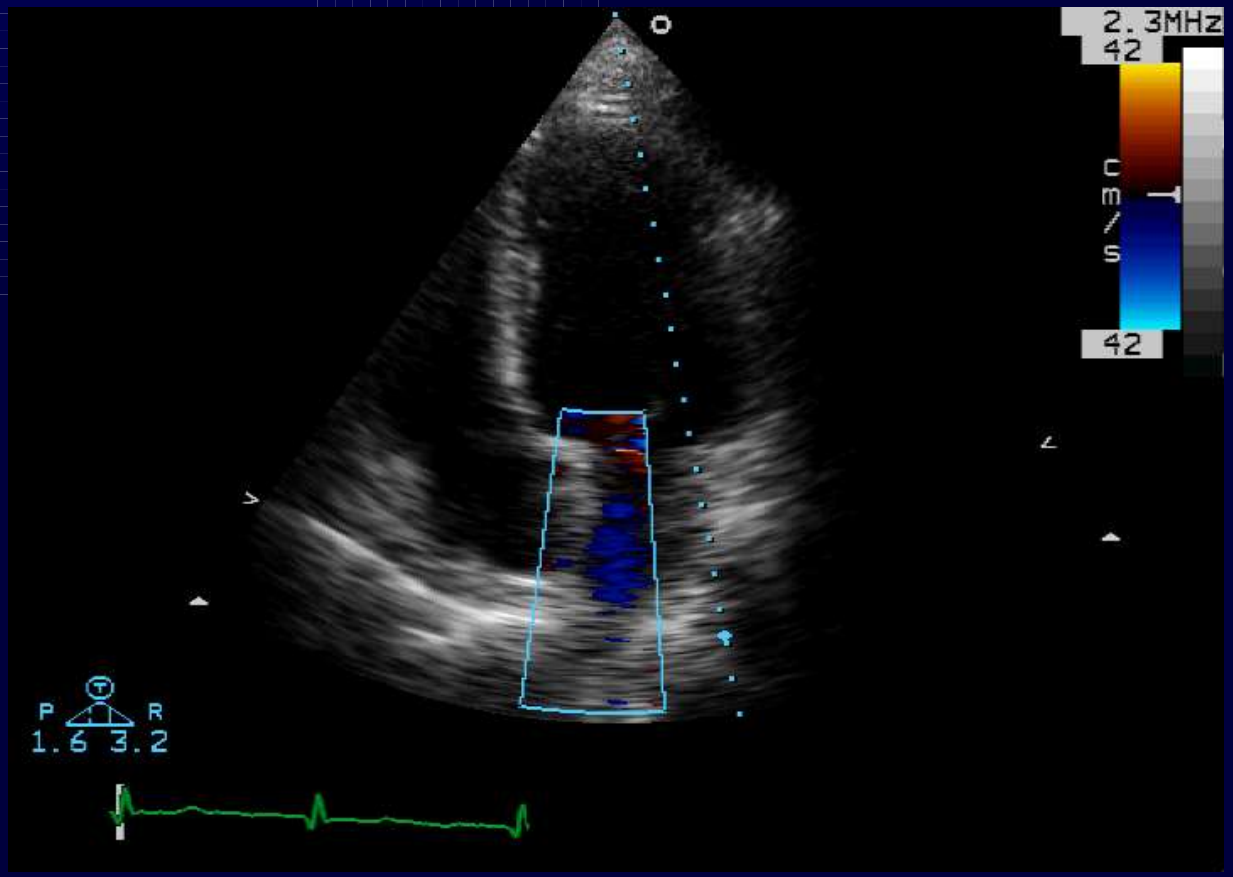
TTE: RSPV

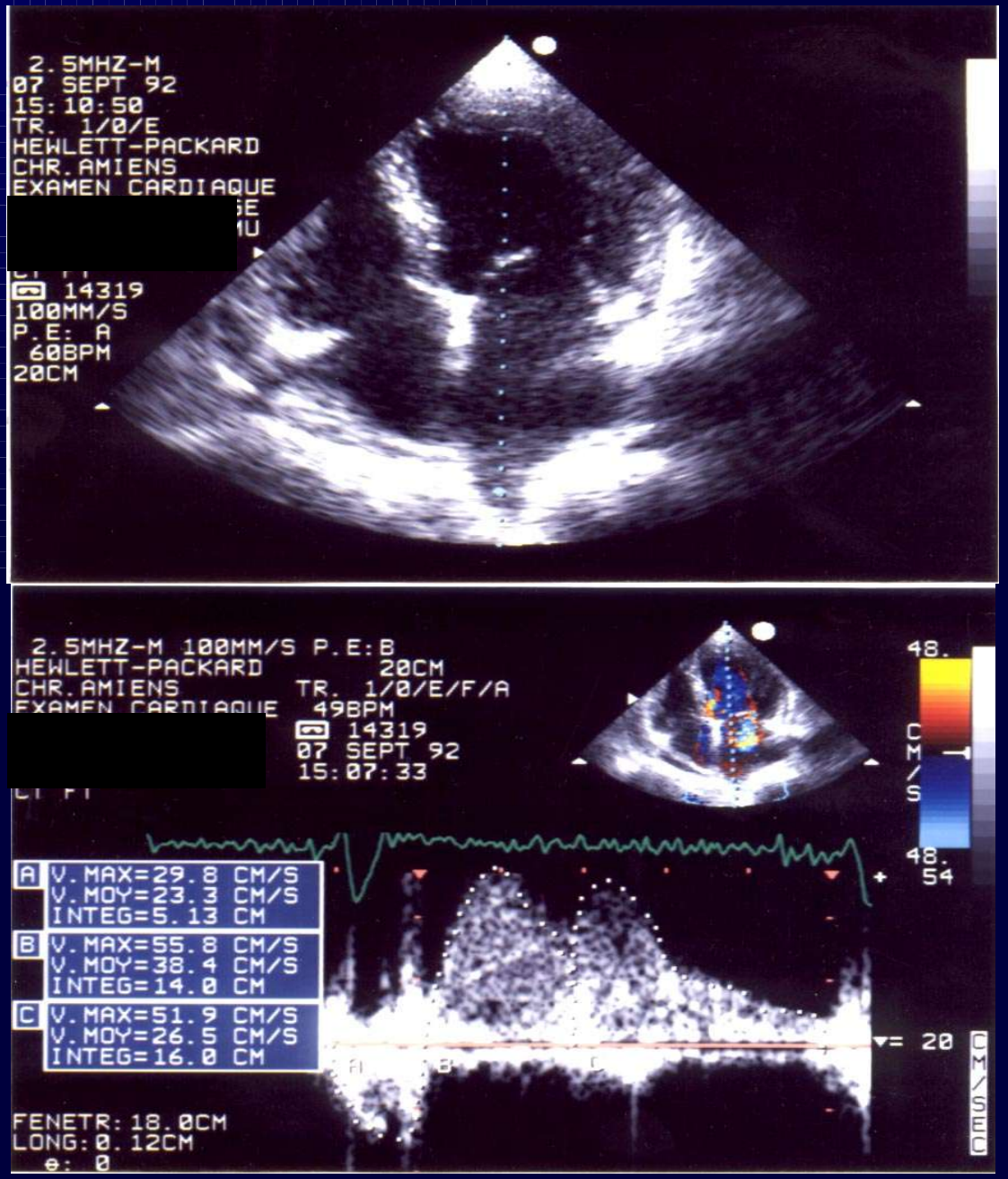
- 4C apical view
- Small window
- 1 - 2cm into PV
- minimum settings
- minimum filters
- 100mm/s
- faisability by TTE:
  - S et D : 70 à 95%
  - Ap : 40 à 90%
- reproductibility Ap (Yamamoto 97)
  10 ± 8ms (inter)



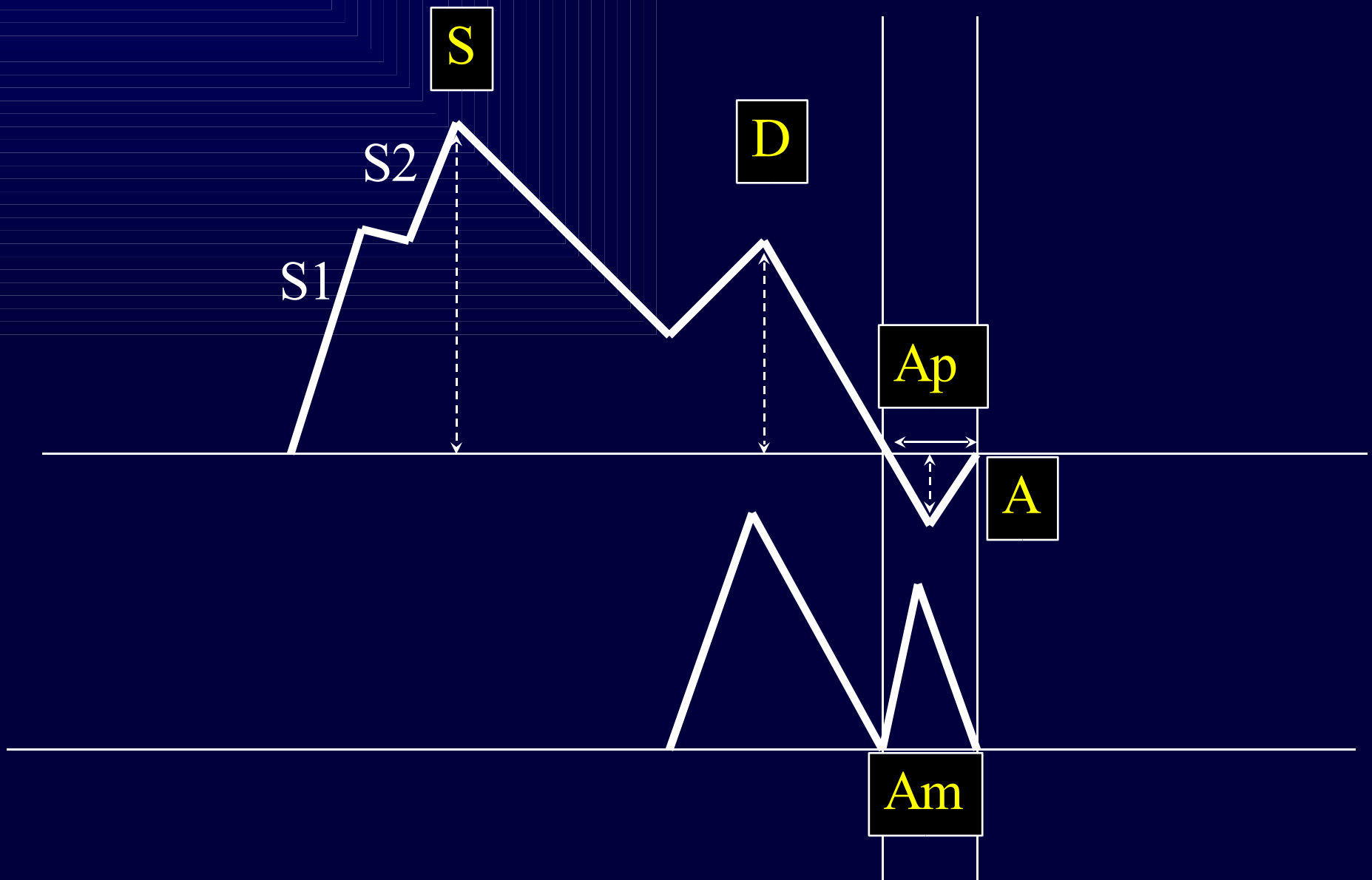
TEE: LSPV

Pulmonary venous flow : how to record ?




2.5MHZ-M
07 SEPT 92
15:10:50
TR. 1/0/E
HEWLETT-PACKARD
CHR.AMIENS
EXAMEN CARDIAQUE
14319
100MM/S
P.E: A
60BPM
20CM
2.5MHZ-M 100MM/S P.E:B
HEWLETT-PACKARD
20CM
CHR.AMIENS
TR. 1/0/E/F/A
49BPM
14319
07 SEPT 92
15:07:33
48.
CM/S
48.54
A V.MAX=29.8 CM/S
V.MOY=23.3 CM/S
INTEG=5.13 CM
B V.MAX=55.8 CM/S
V.MOY=38.4 CM/S
INTEG=14.0 CM
C V.MAX=51.9 CM/S
V.MOY=26.5 CM/S
INTEG=16.0 CM
= 20
FENETR: 18.0CM
LONG: 0.12CM
e: 0

Pulmonary veinous flow : what to mesure ?



Normal values for pulmonary venous flow

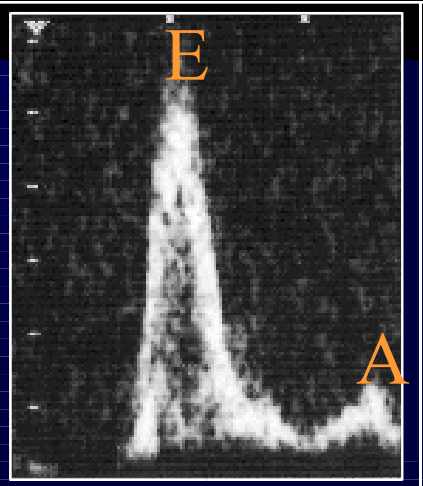
- S : 65 ± 15 cm/s
- D : 45 ± 14 cm/s
- A : -18 ± 7 cm/s

Normal values :
- **S/D > 1**
- **Ap < 35 cm/s**
- **durée Ap ≤ Am**
- **FS > 55%**

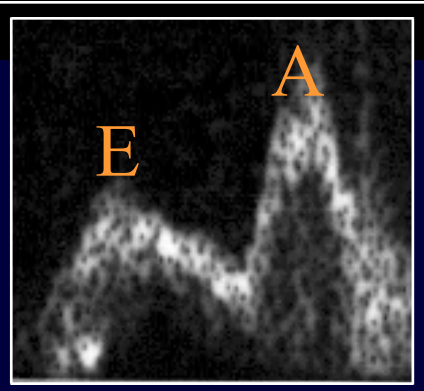
- Duration A : 140 ± 35 ms (60 à 230 ms) < duration A (mitral)
- Systolic fraction : $\frac{VTIS}{VTI\ S + VTI\ D} = 66 \pm 10\%$

Effect of age on pulmonary venous flow

Young :
- ↗E ↘A ↗E/A
- ↘DTE

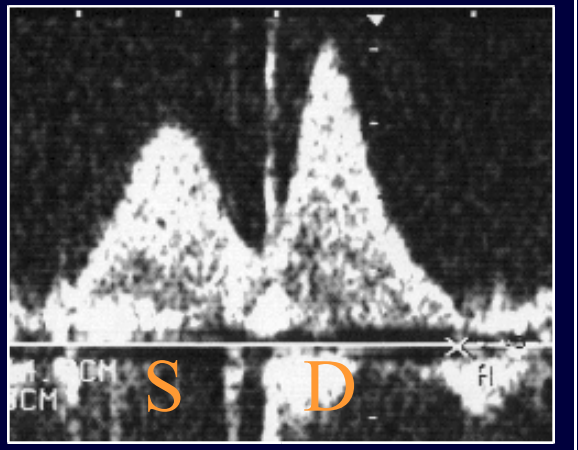


Aged :
- ↘E ↗A ↘E/A
- ↗DTE

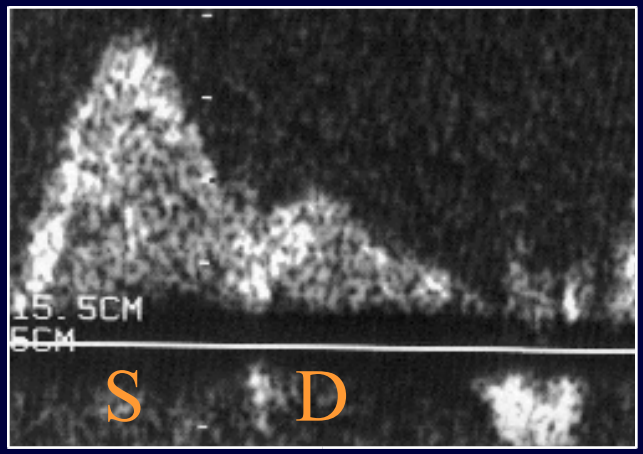


E/A < 1 in 85% of > 70 ans (Sagie et al. JASE 1993)

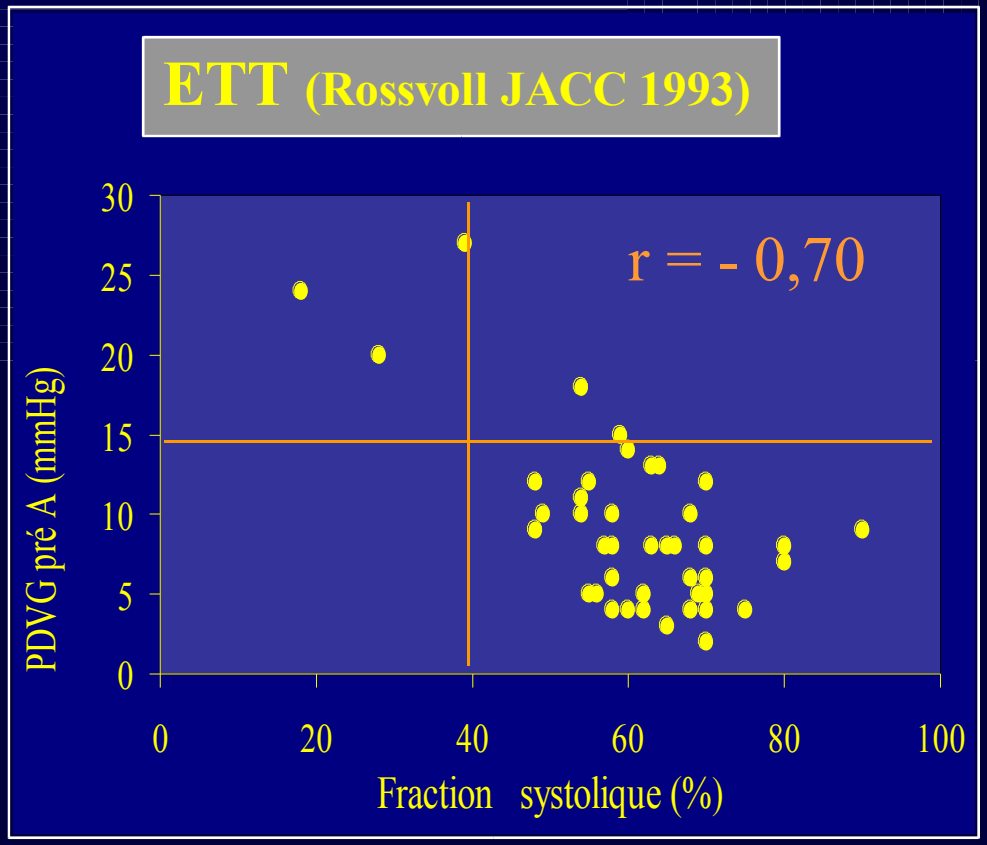
- S/D <1

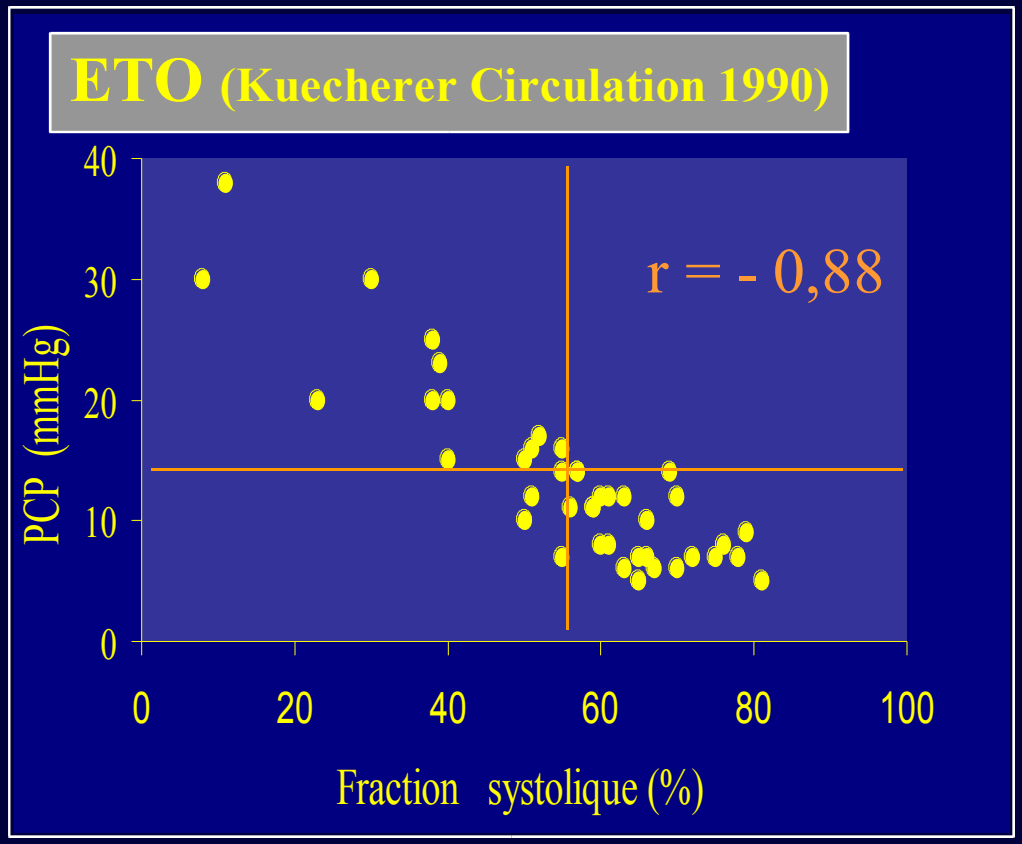


- S/D > 1



LV diastolic pressure and systolic fraction



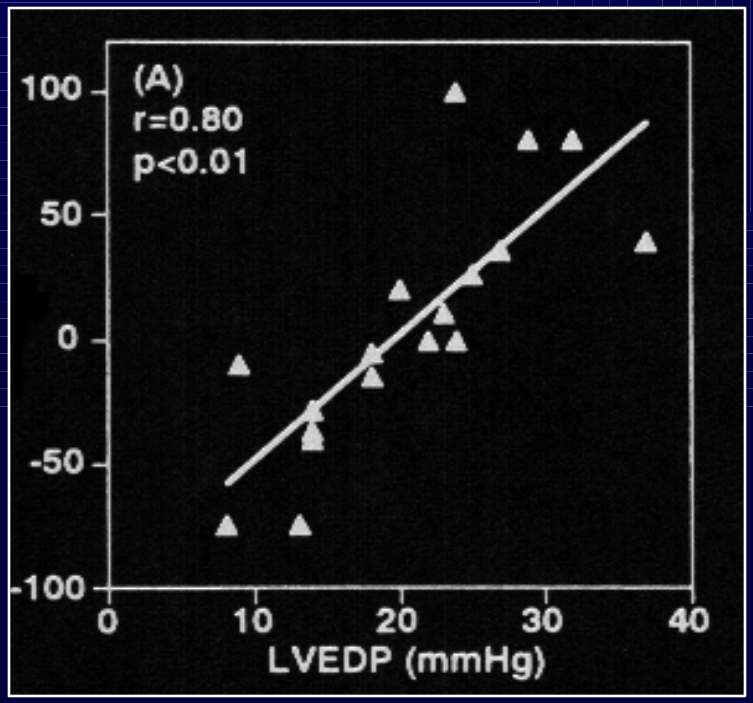


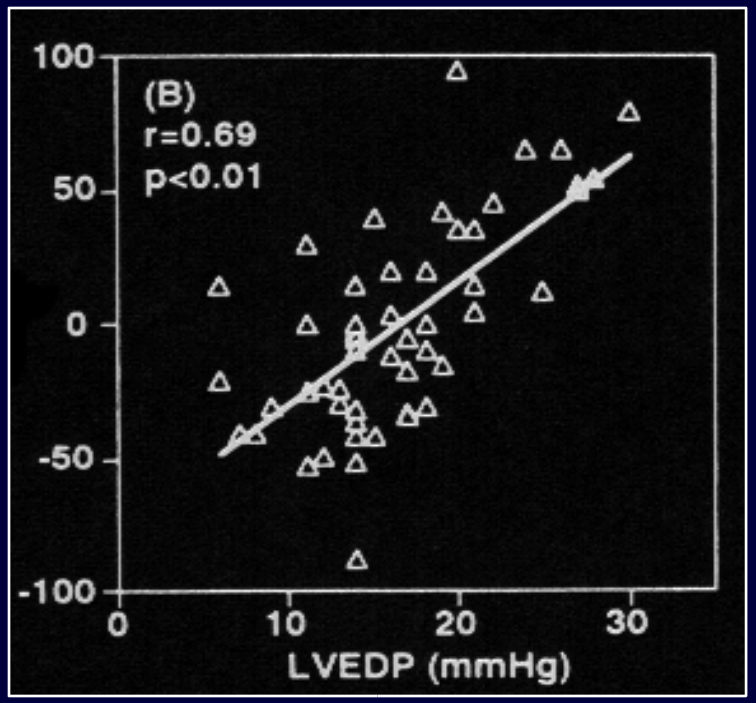
SF< 40% ⟶ LVDP préA> 15mmHg

SF < 55% ⟶ PWP ≥ 15 mmHg

Corrélation Ap - Am et LVEDP

(Yamamoto et al. JACC 1997;30:1819-26)





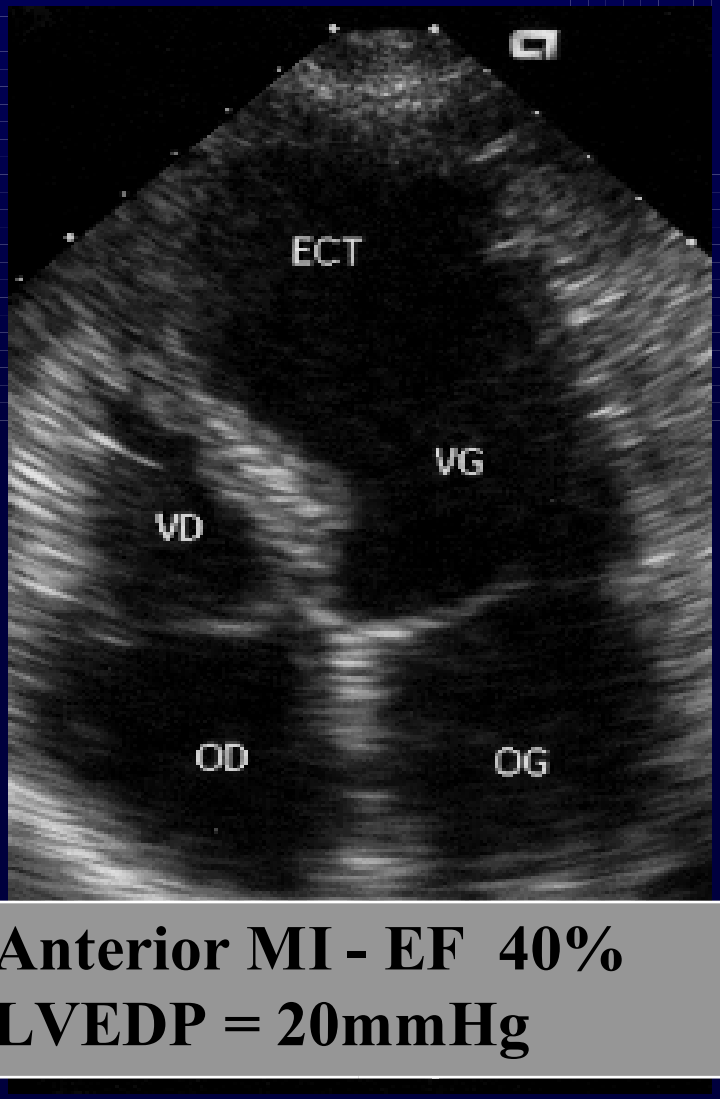
EF< 50% r=0,80

EF >50% r = 0,69

Ap > Am : LVEDP > 15mmHg (Se : 85%, Sp: 79%, Rossvoll)

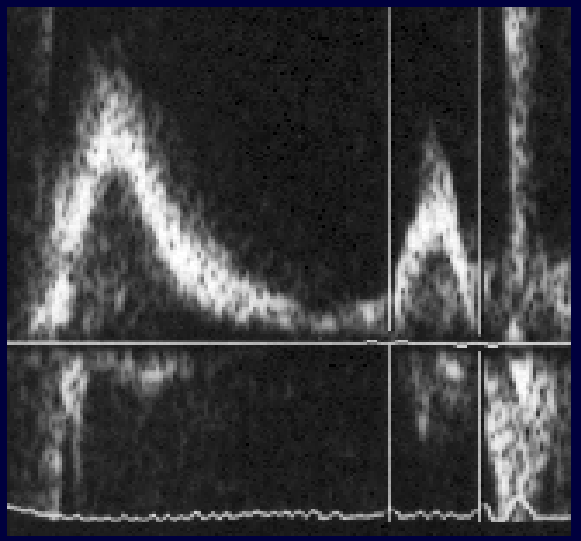
Ap - Am >20ms : LVEDP > 12mmHg (Se : 74%, Sp: 95%,Appleton)

Ap - Am

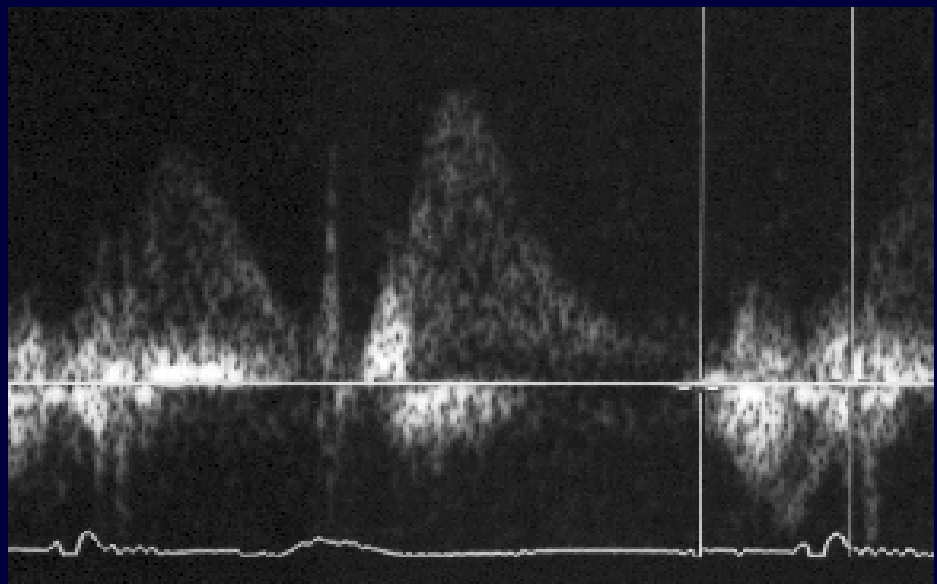


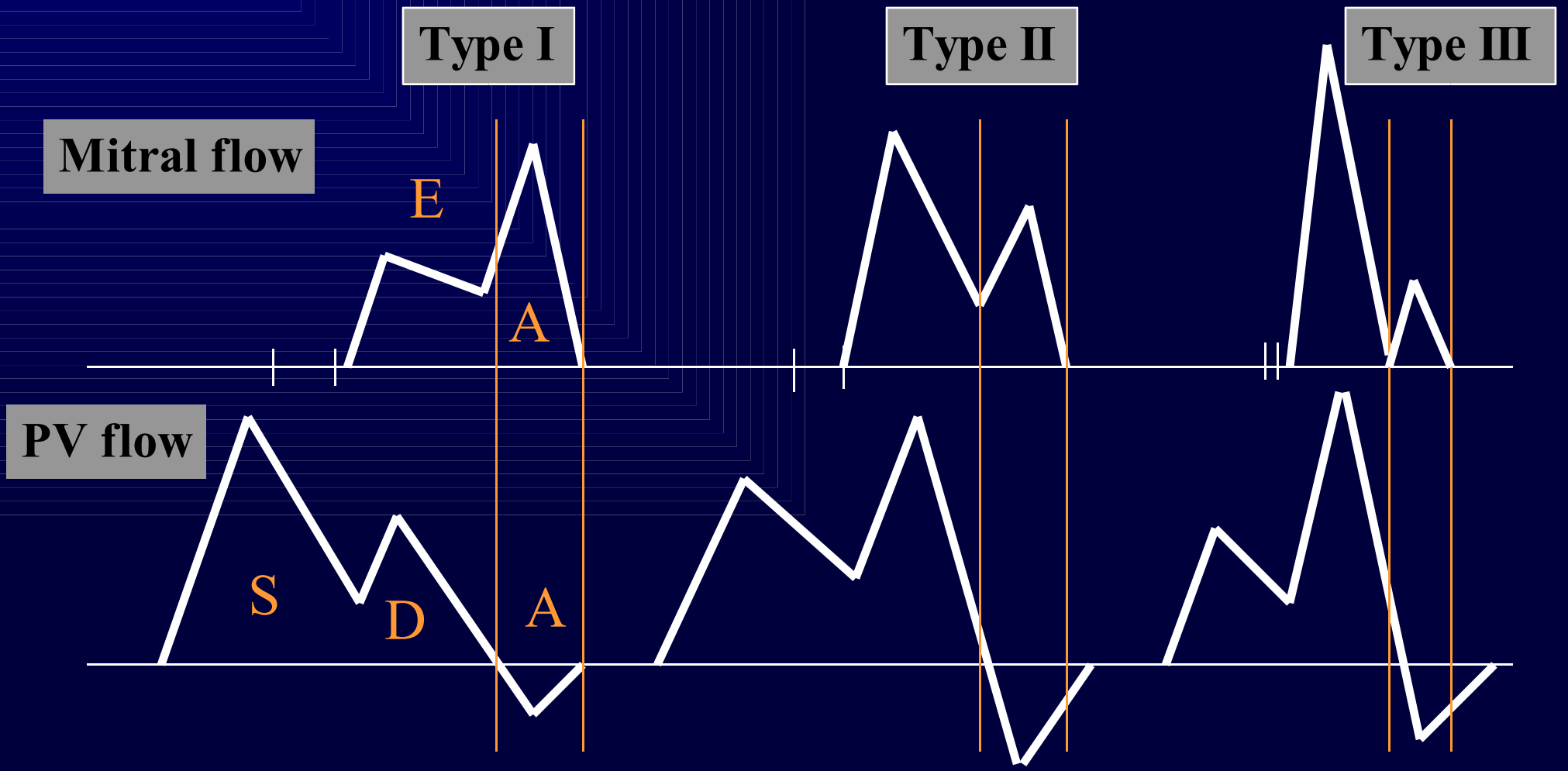
Anterior MI - EF 40%
LVEDP = 20mmHg

Am = 120 ms



SF=40%, Ap = 220 ms

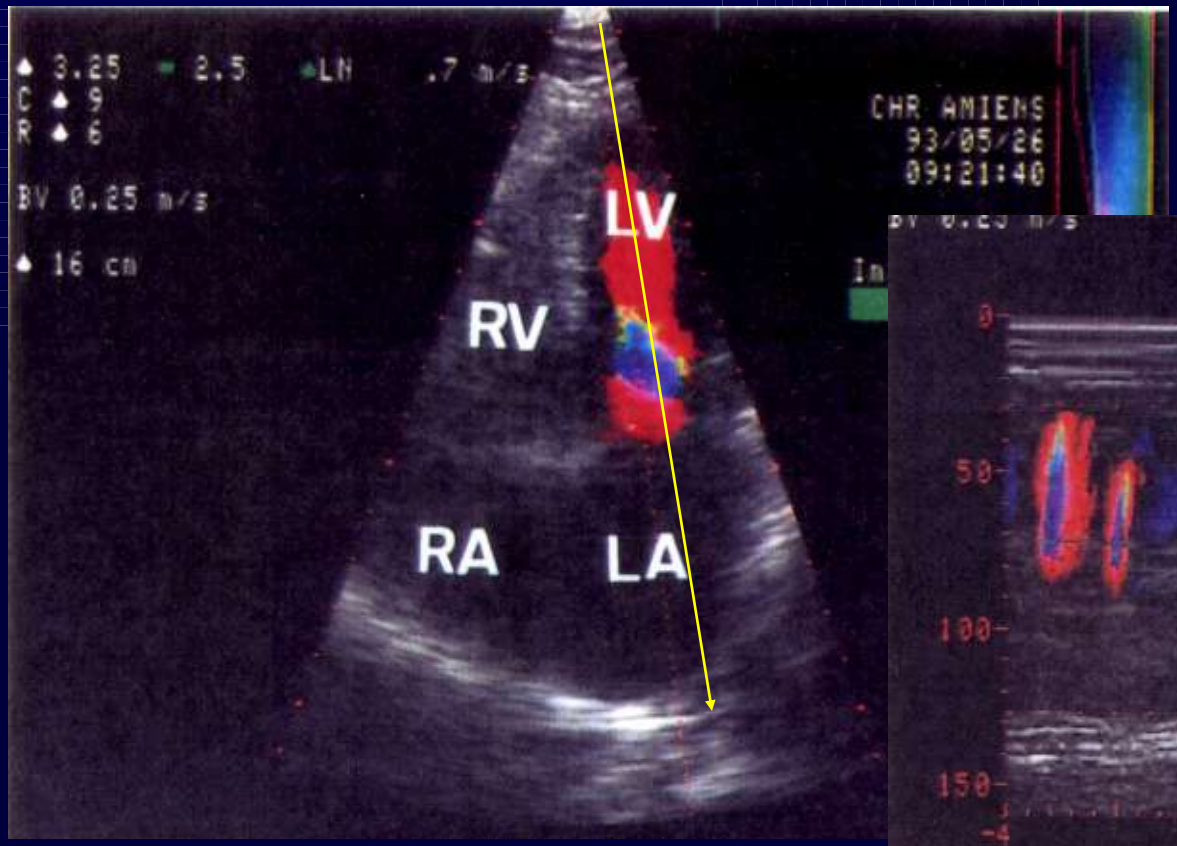


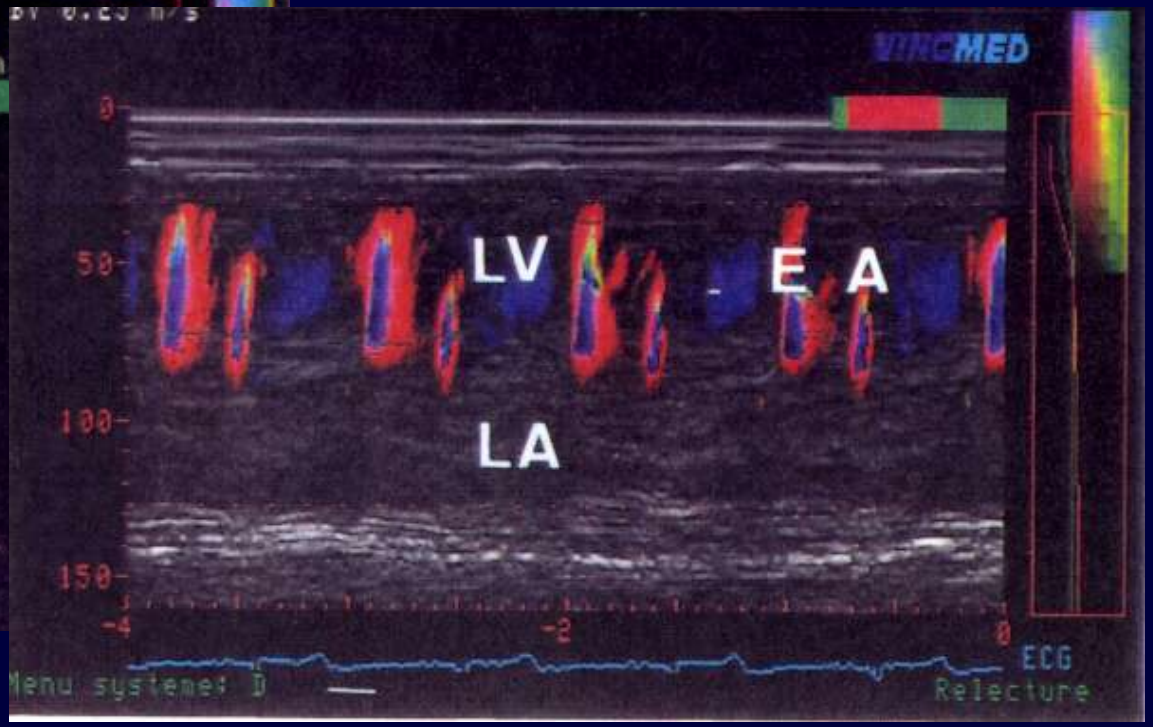


Appleton et al

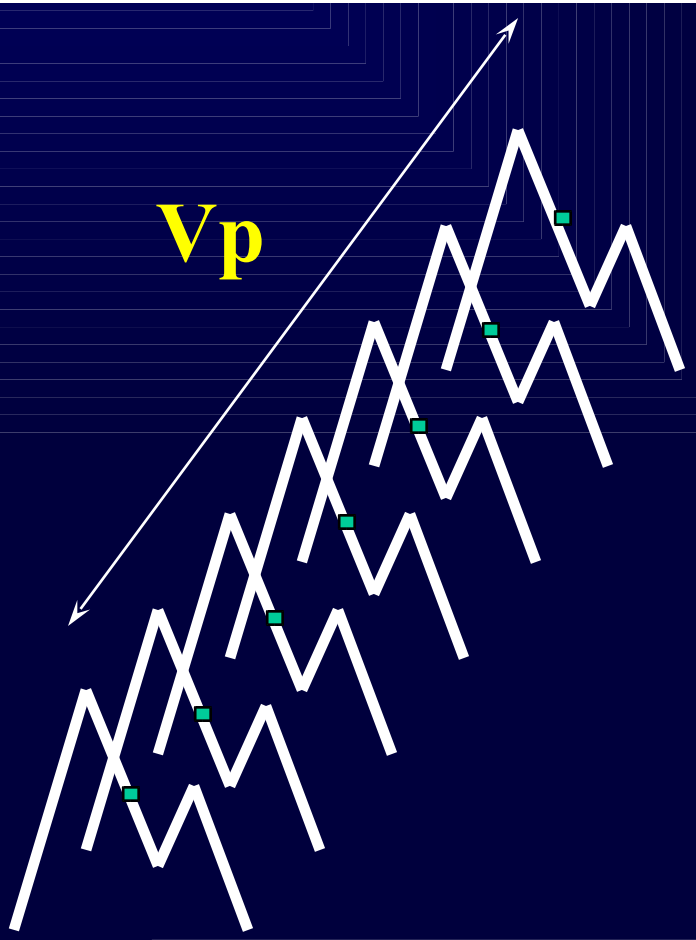
III Mitral flow propagation velocity (Color M-Mode)

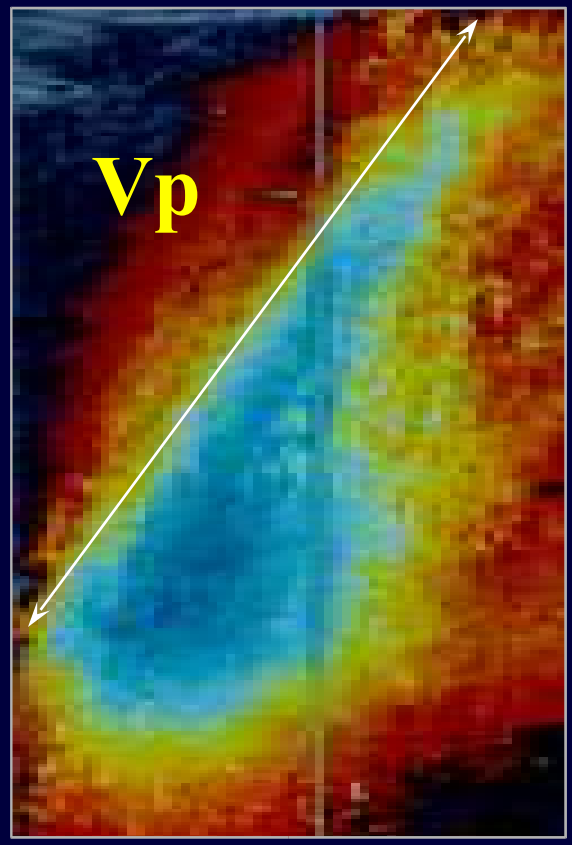
Mitral flow propagation velocity (Vp) (Color M-Mode)





Mitral flow propagation velocity (Color M-Mode)

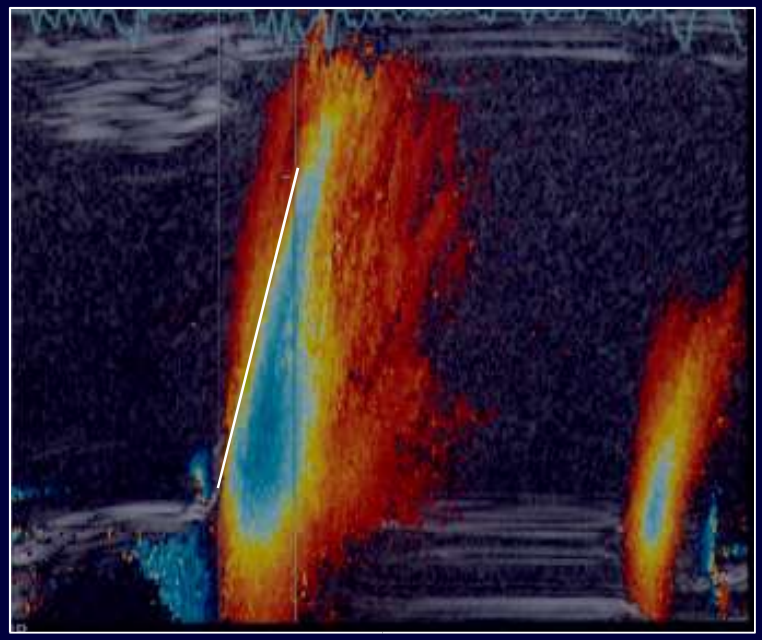




Vp = slope of isovelocities
= LV relaxation index

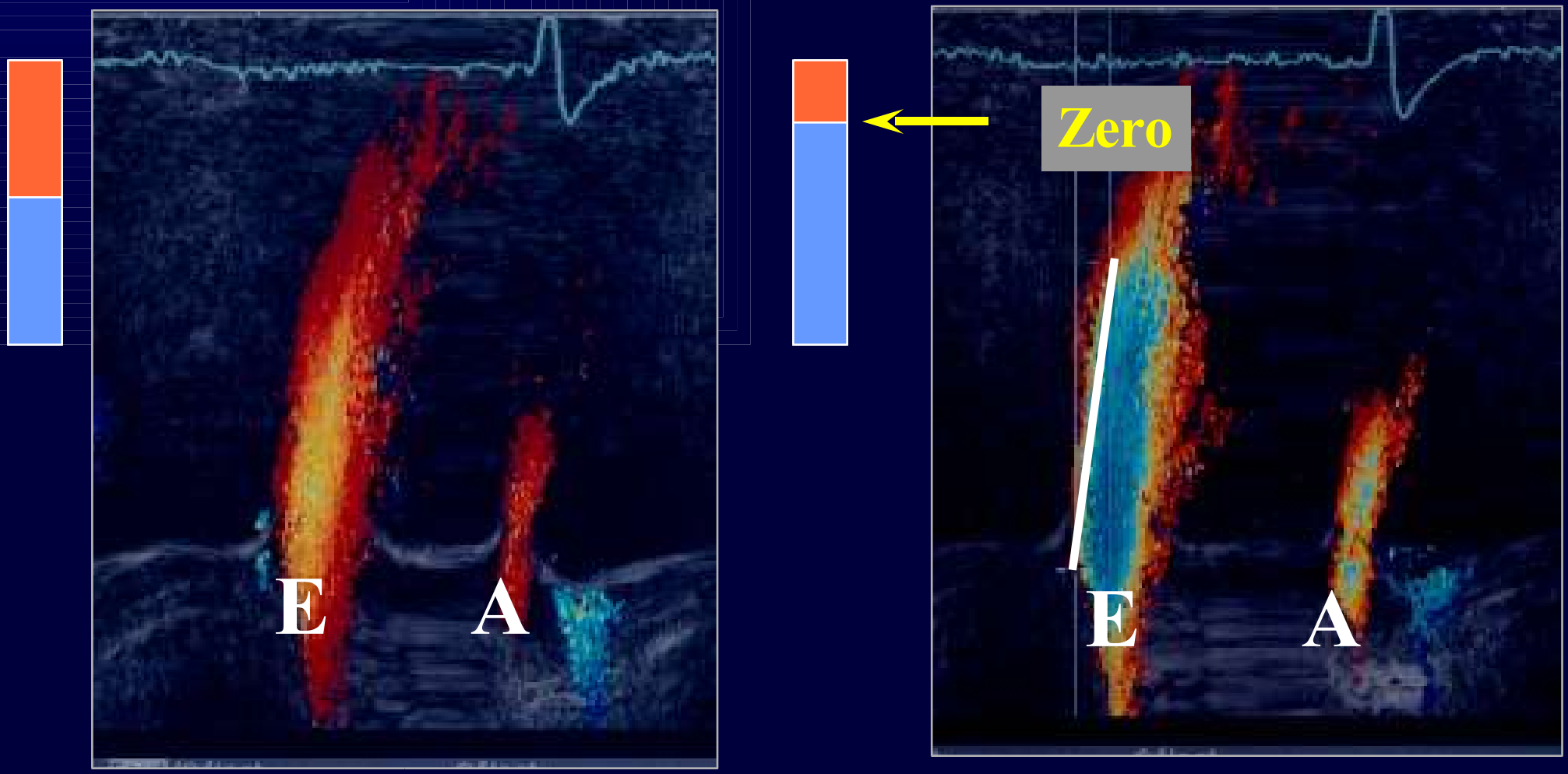
Mitral flow propagation velocity (Color M-Mode) : how to measure?

- 4C apical view
- Color Doppler
- M-mode
- 100 mm/s
- Aliasing limit : 50% to 75% E velocity
- Mesure of Vp :
  - Slope of isovelocity first aliasing (interface between orange and blue)
  - Mitral annulus to 4 cm into LV
  - Average of 3 measurements

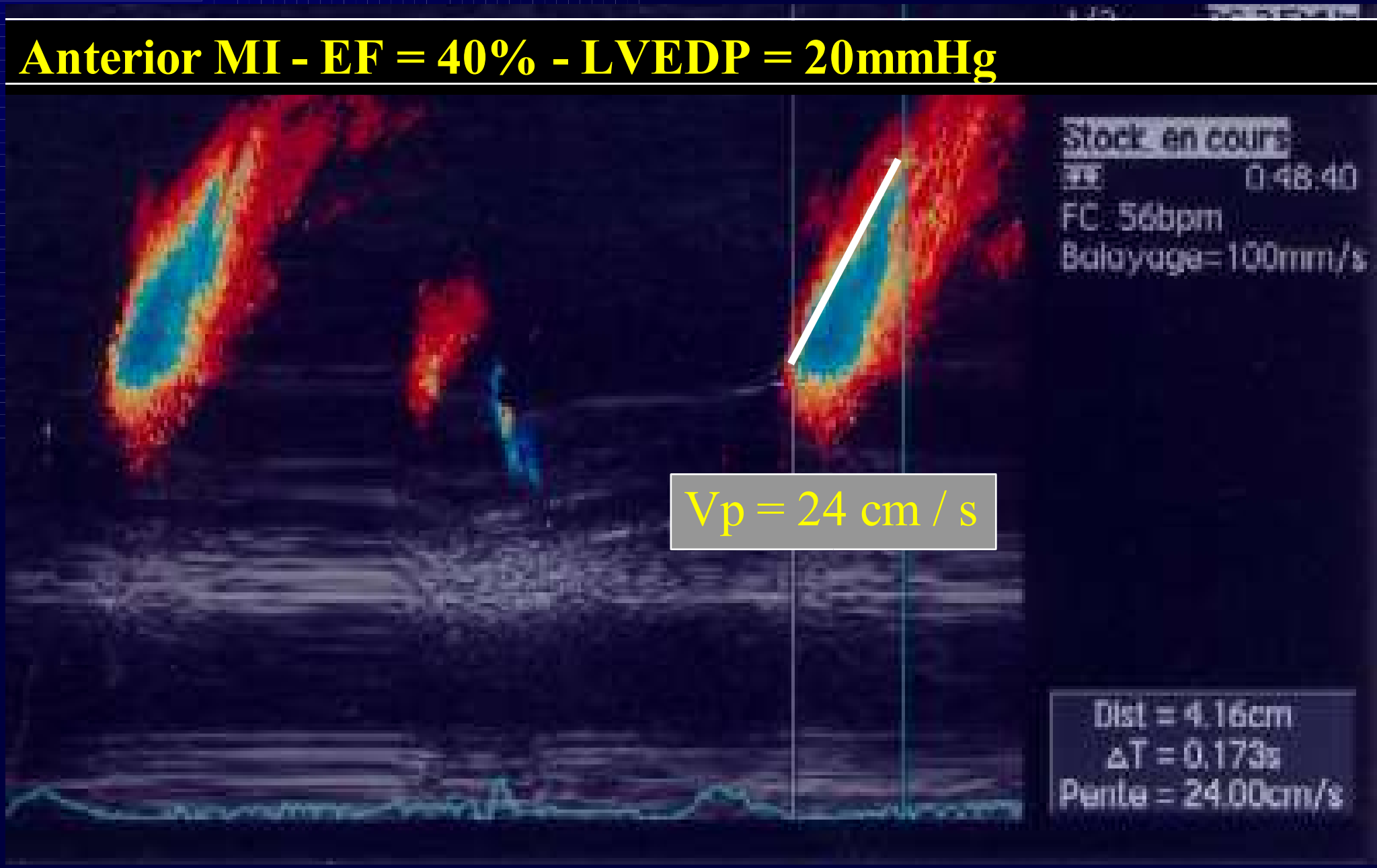


Vp > 45 cm/s

Vp : measurement



Anterior MI - EF = 40% - LVEDP = 20mmHg



Mitral flow propagation velocity (Color M-Mode)

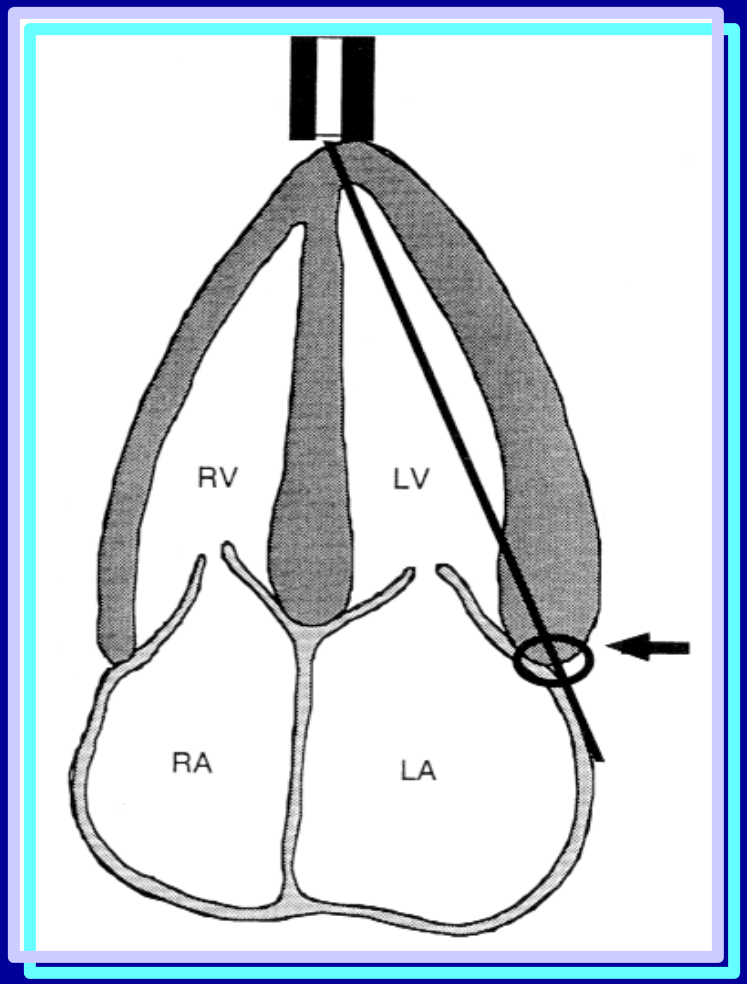
- Relaxation index
- Preload independant
- To distinguish normal and pseudo normal MF
- Recordable in 80% of patients
- Limits : influence of age

Vp : influence of age

Normal values(Mego et al. JASE 1998; 11: 20-5)

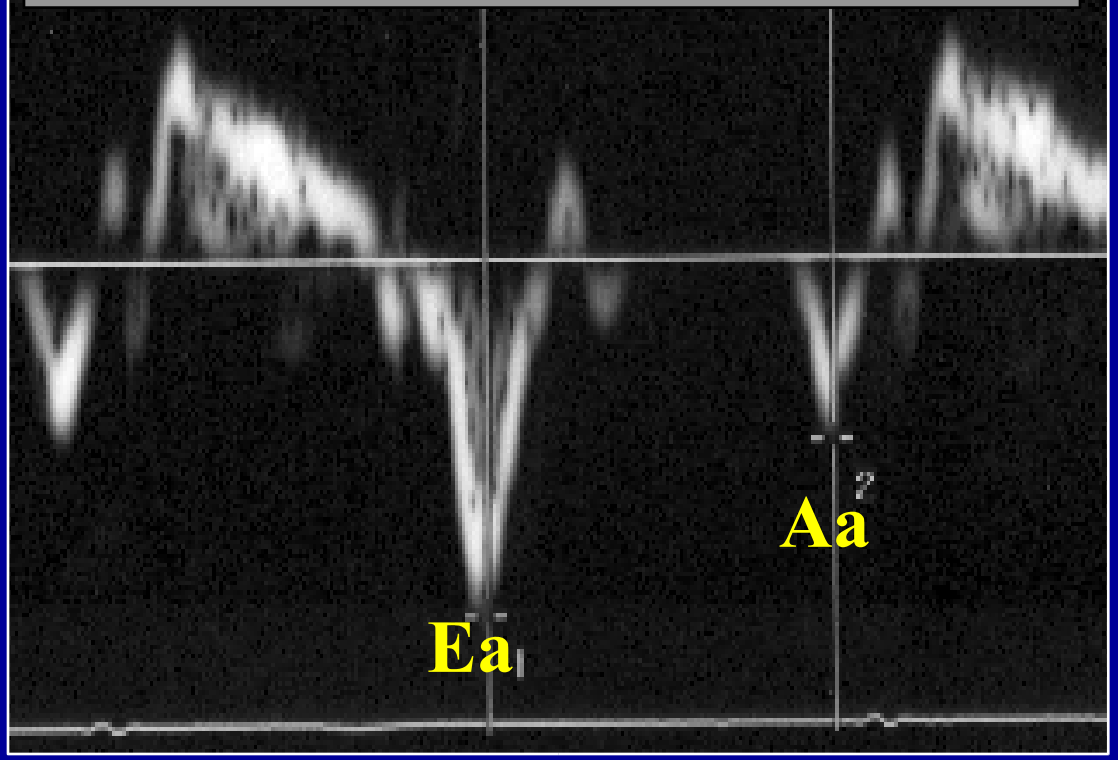
Age (years)	Vp (cm/s)
21-35	77 ± 25
36-50	70 ± 23
51-60	53 ± 15
> 65	43 ± 11

IV Mitral annulus movement (DTI)



Normal values

Ea > 8 cm/s et Ea / Aa > 1

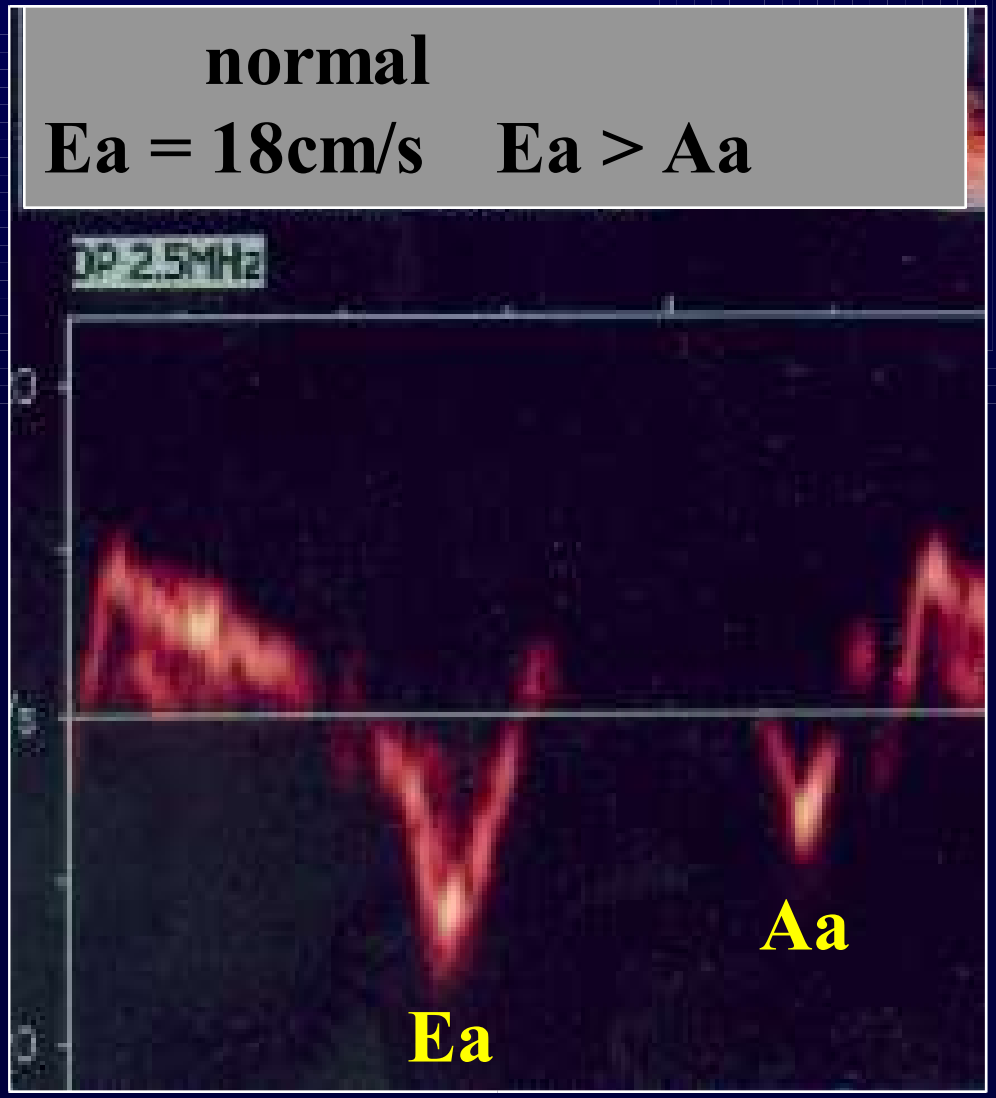


- **DTI**
- **Mitral annulus**
- **Minimum settings**

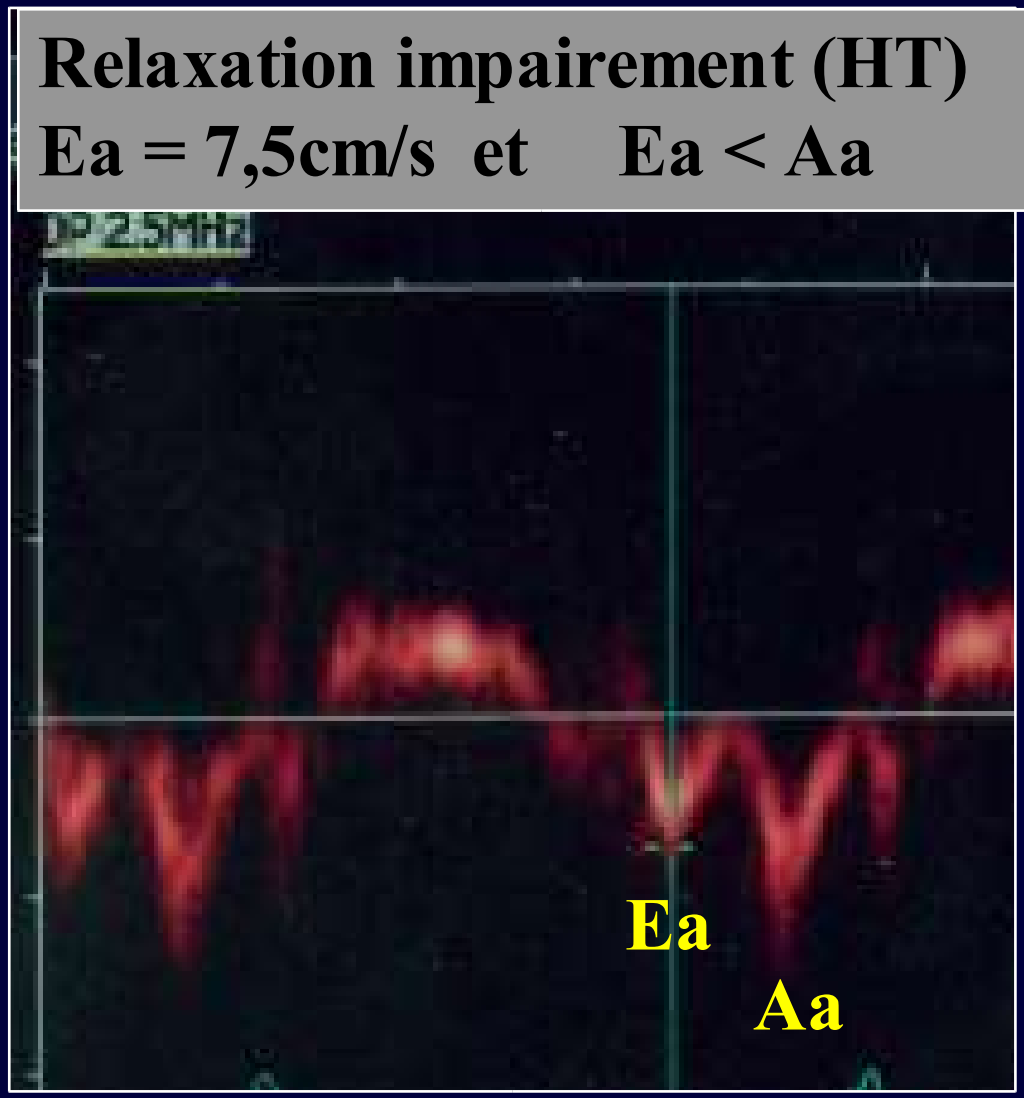
- **Ea = 15 ± 4 cm/s**
  Aa = 10 ± 3 cm/s

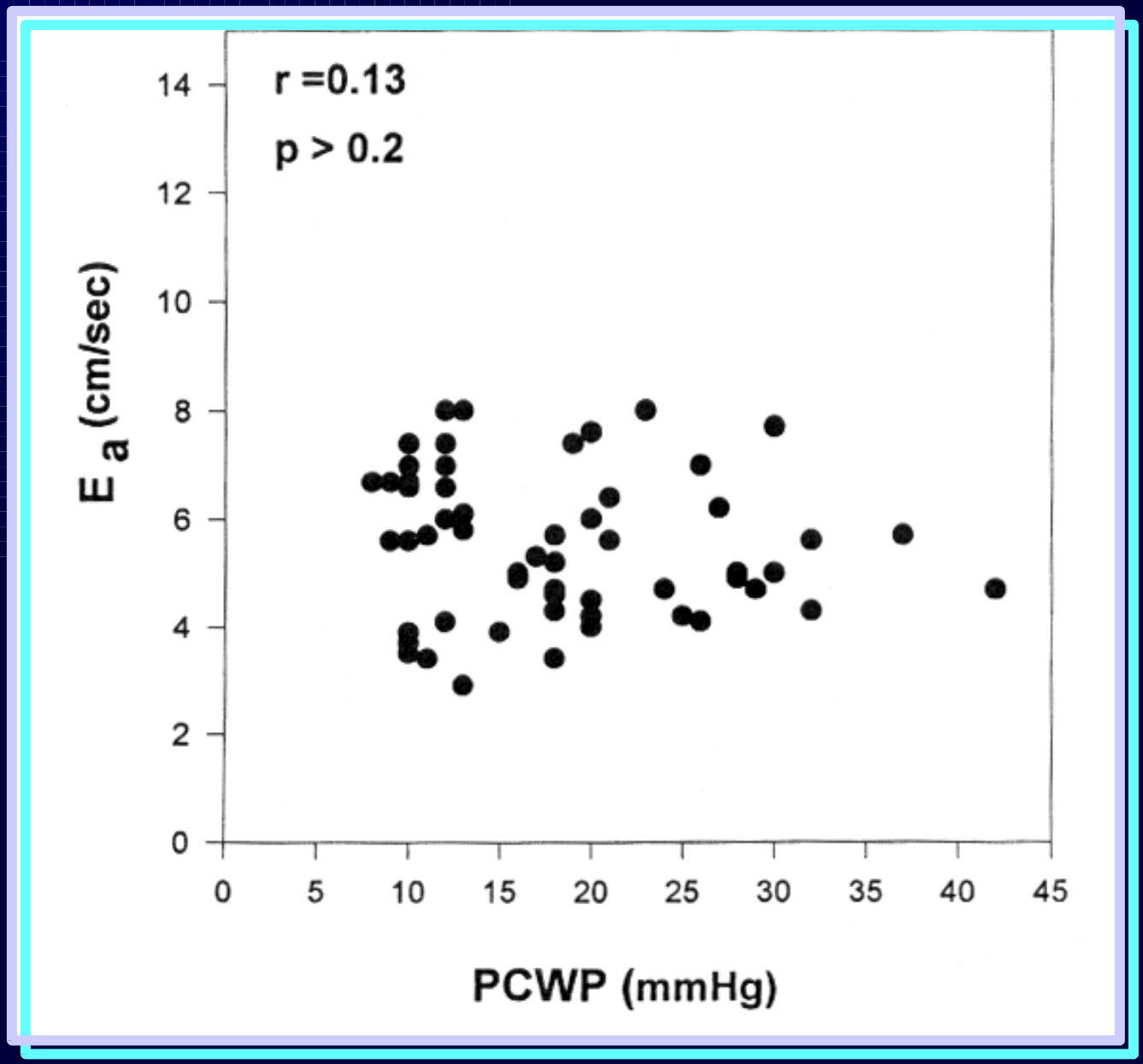
Mitral annulus movement

normal
Ea = 18cm/s Ea > Aa



Relaxation impairement (HT)
Ea = 7,5cm/s et Ea < Aa



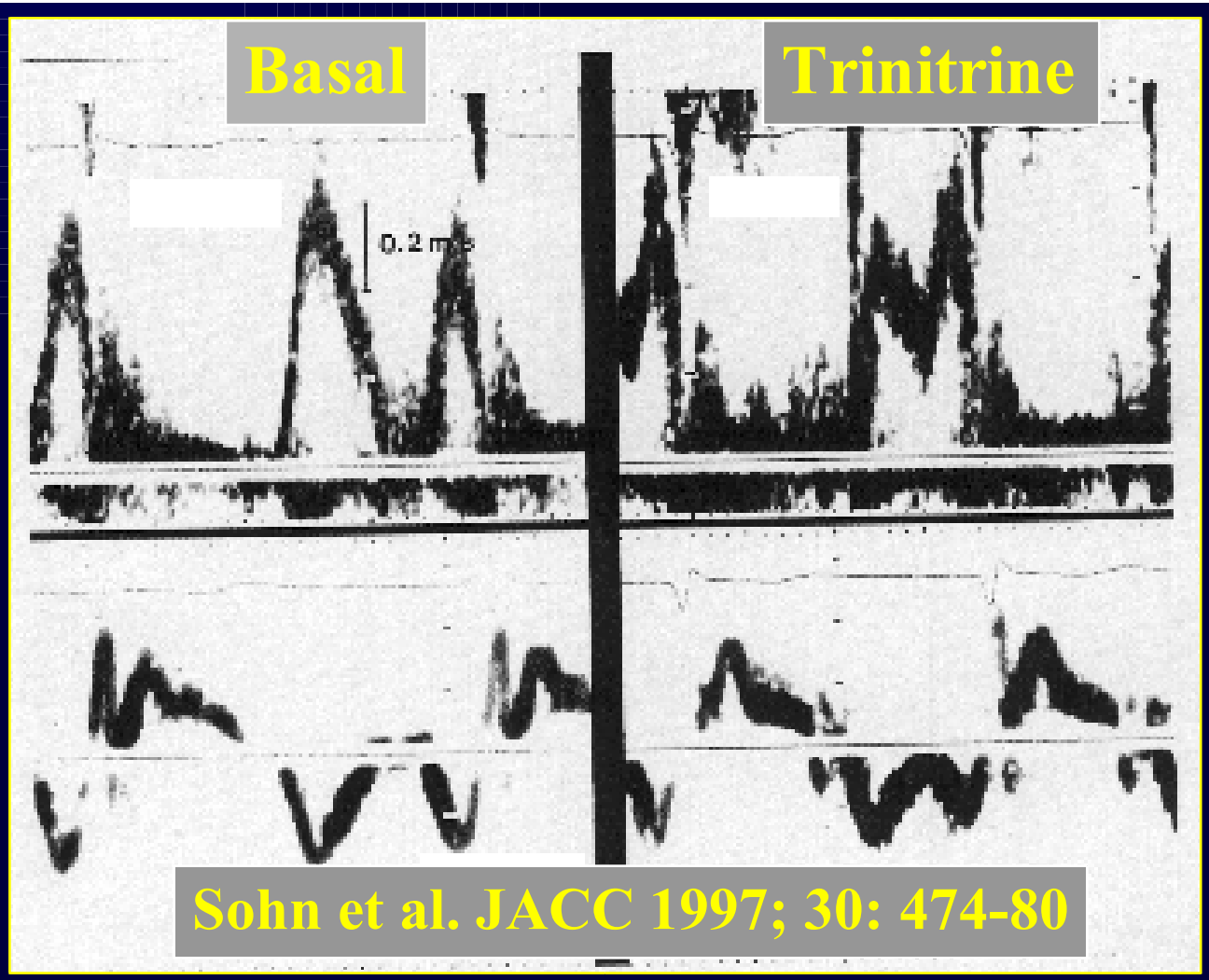


Nagueh, JACC 1997

Preload effect on mitral annulus DTI

Mitral flow

DTI

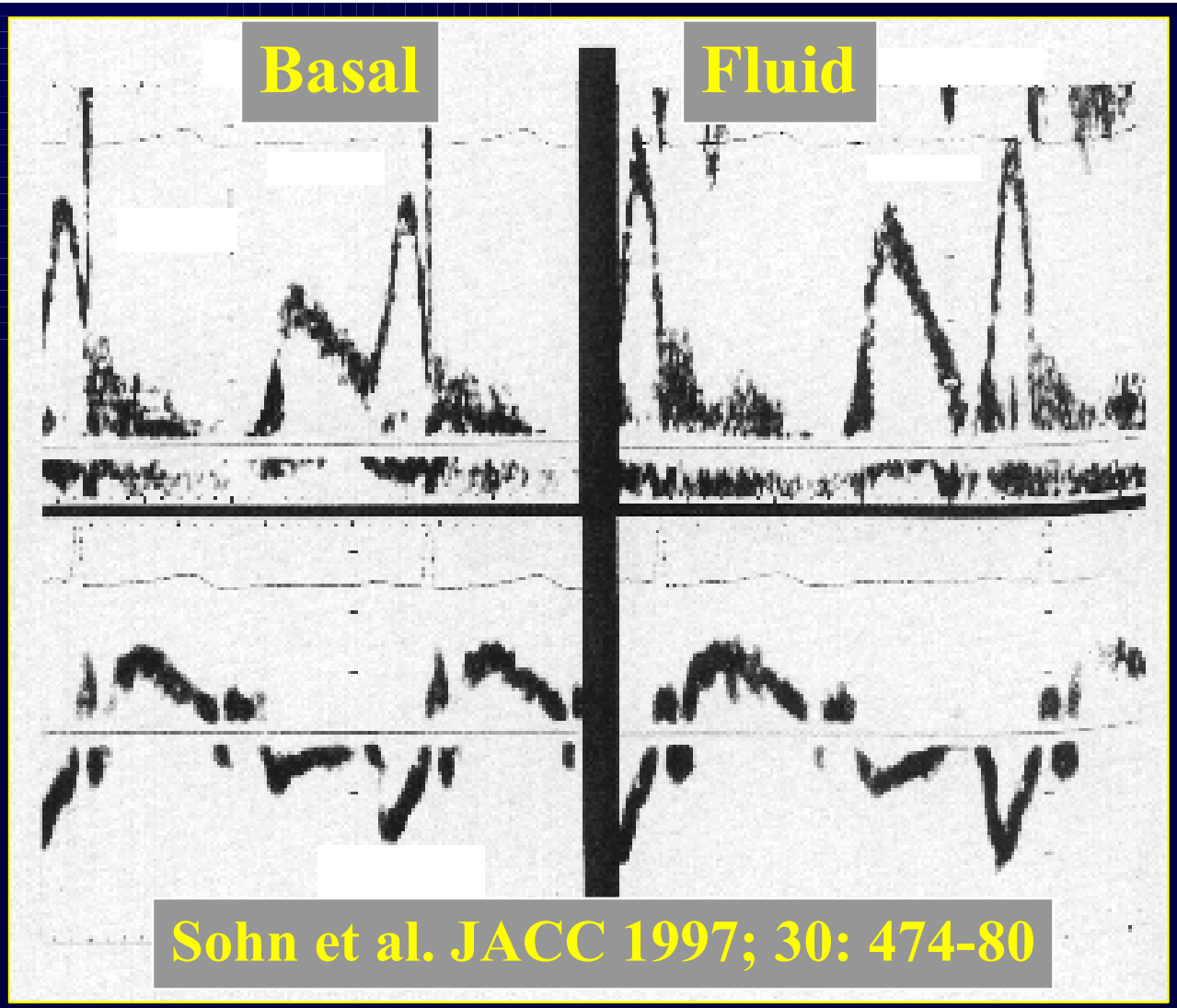


Sohn et al. JACC 1997; 30: 474-80

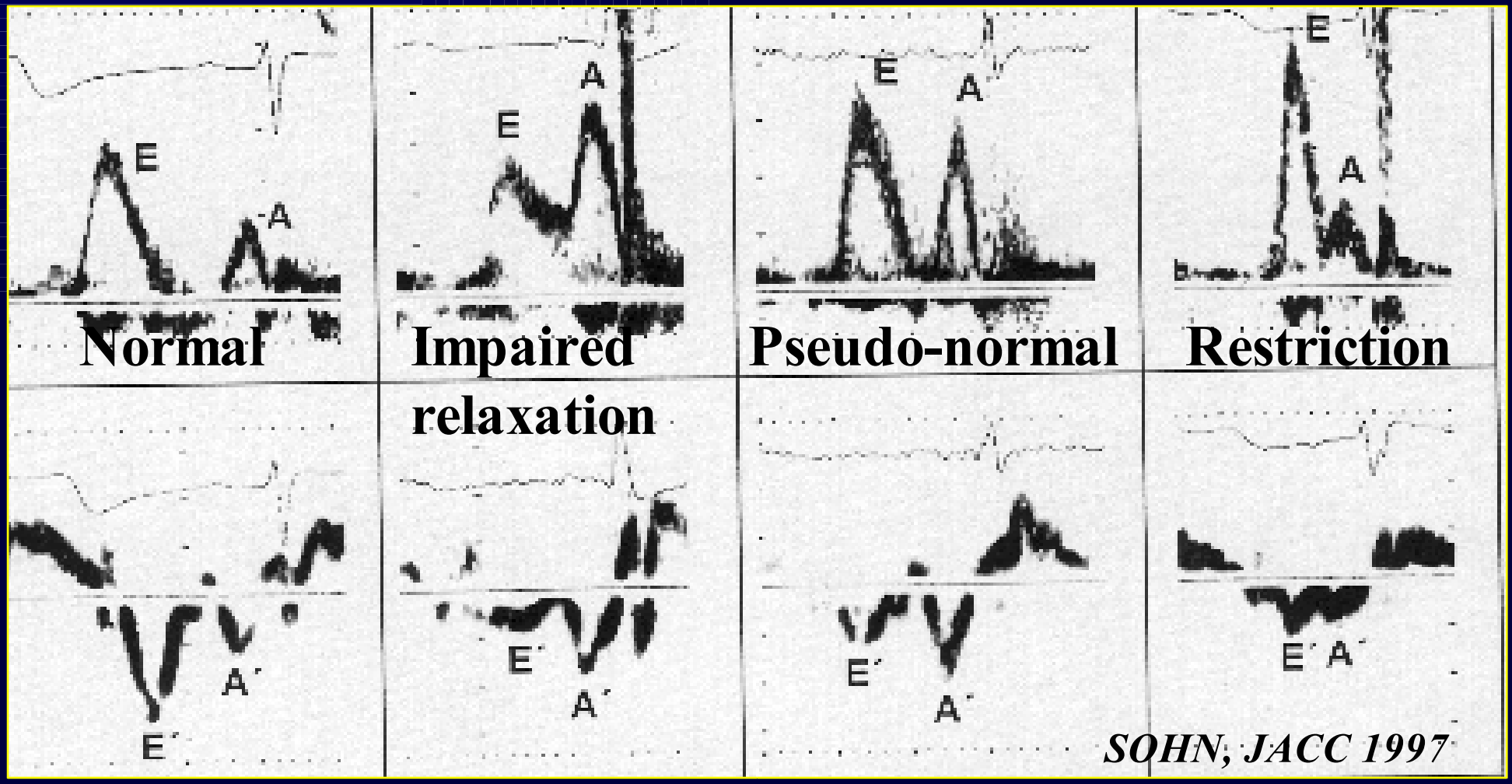
Preload effect on mitral annulus DTI

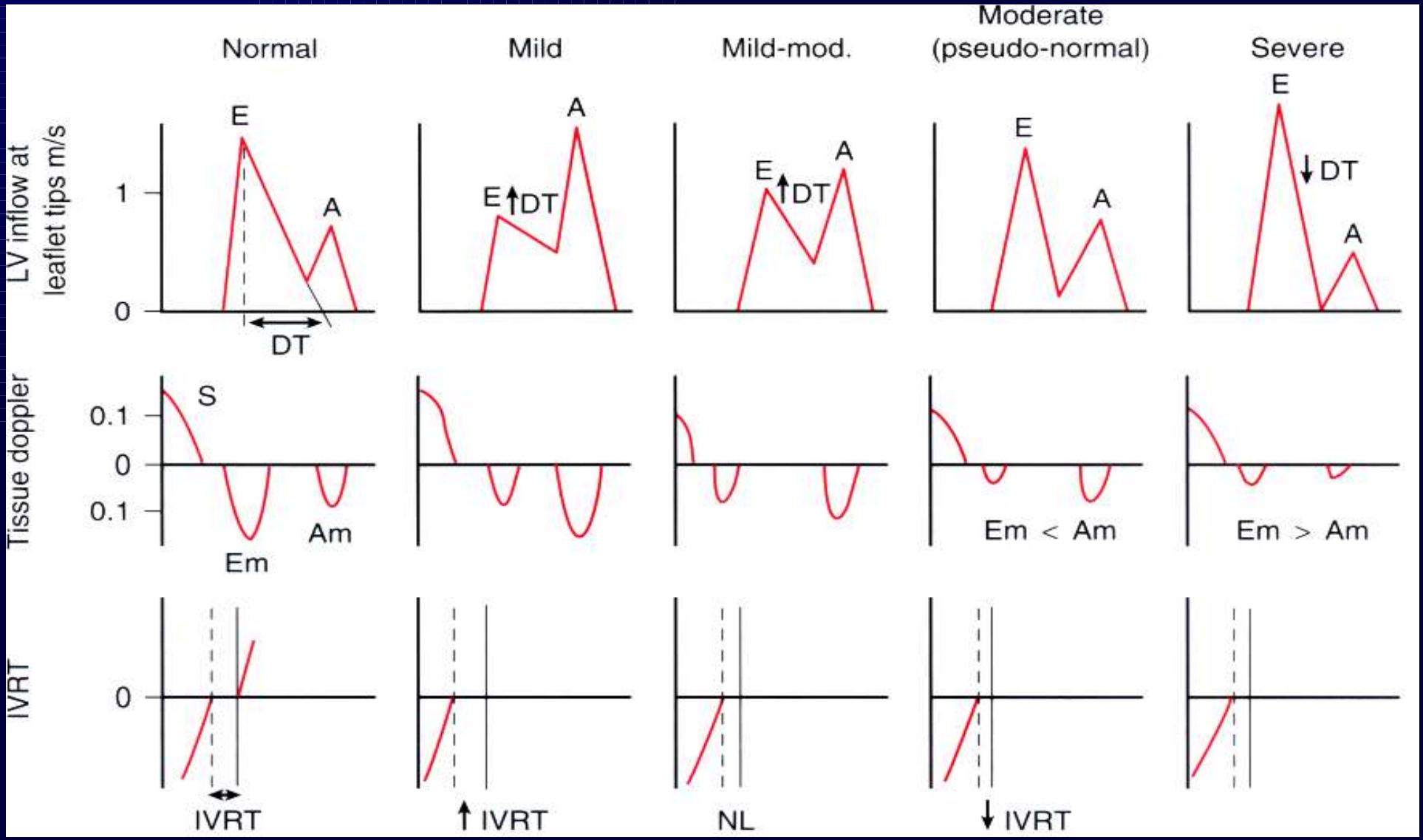
Mitral flow

DTI (Annulus)



Mitral annulus movement (DTI)




Normal
Mild
Mild-mod.
Moderate
(pseudo-normal)
Severe
LV inflow at leaflet tips m/s
1
0
E
A
DT
E
A
DT
E
A
DT
E
A
E
DT
A
Tissue doppler
0.1
0
0.1
S
Em
Am
Em < Am
Em > Am
IVRT
0
IVRT
IVRT
NL
IVRT

Conclusion

- In ICU many factors influence mitral flow and pulmonary venous flow (age, HR, LVDP, compliance, relaxation)
- These indice may not be used to assess LV diastolic function (compliance and relaxation)
- To assess relaxation : Vp and Ea/Aa