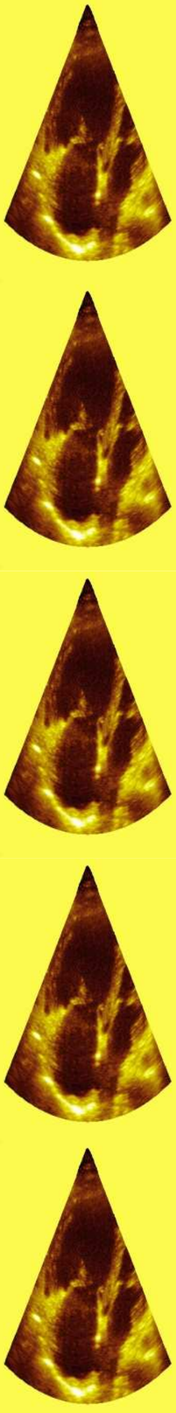
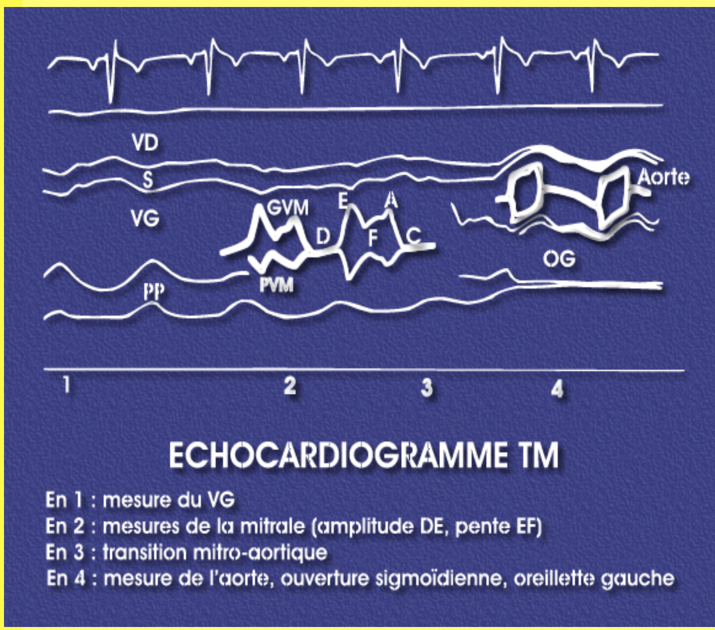
Evaluation de la fonction ventriculaire gauche

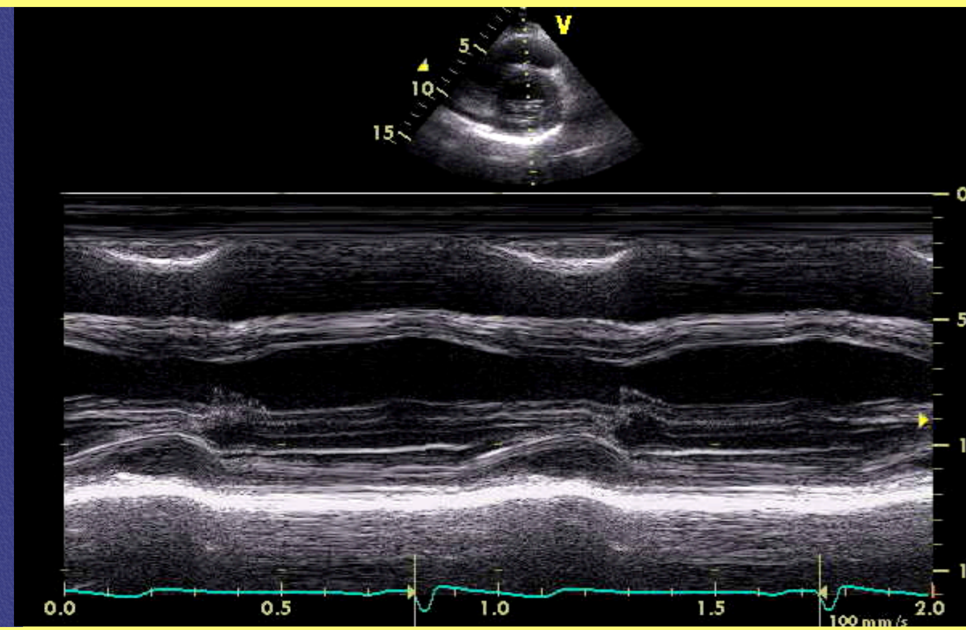


Christine Selton-Suty

Les différentes techniques

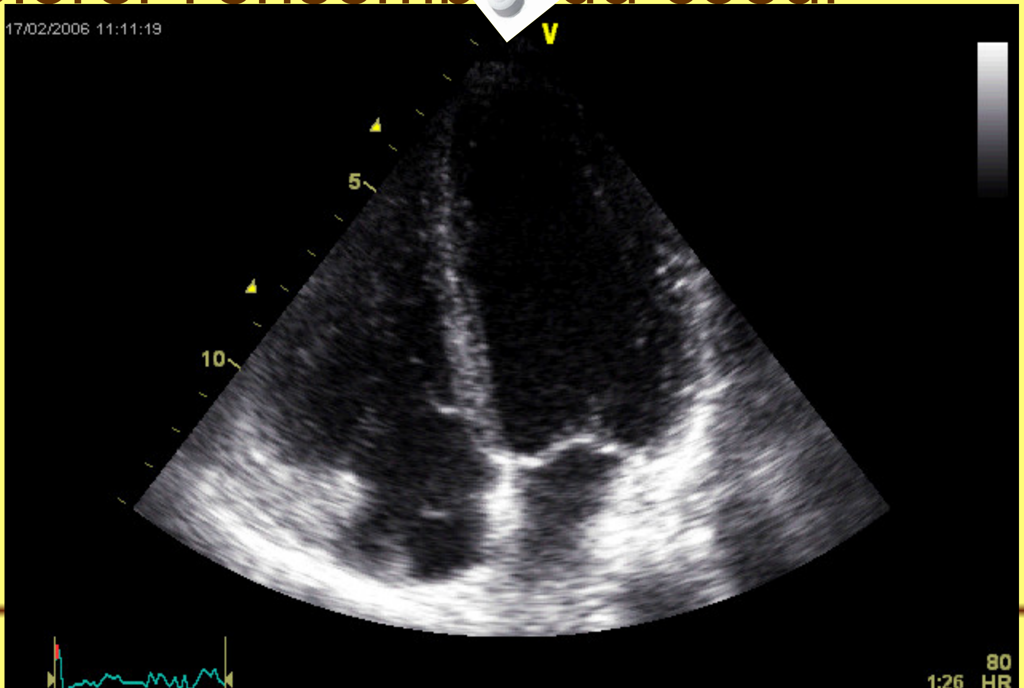
- Mode M (Time Motion)
  - En X le temps, en Y l'espace
  - Mesure précise de la chronologie et des dimensions.





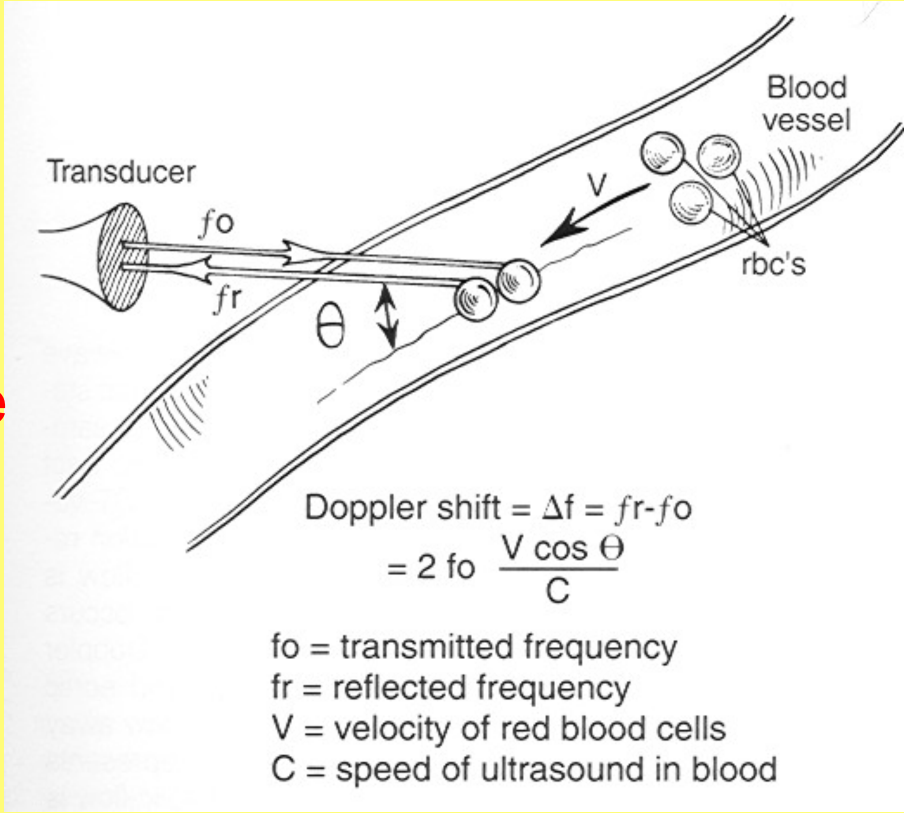
Les différentes techniques

- Imagerie bidimensionnelle (mode 2D)
  - Présentation X-Y de l’espace : vision monoplan
  - Donc nombreuses incidences pour explorer l'ensemble du coeur

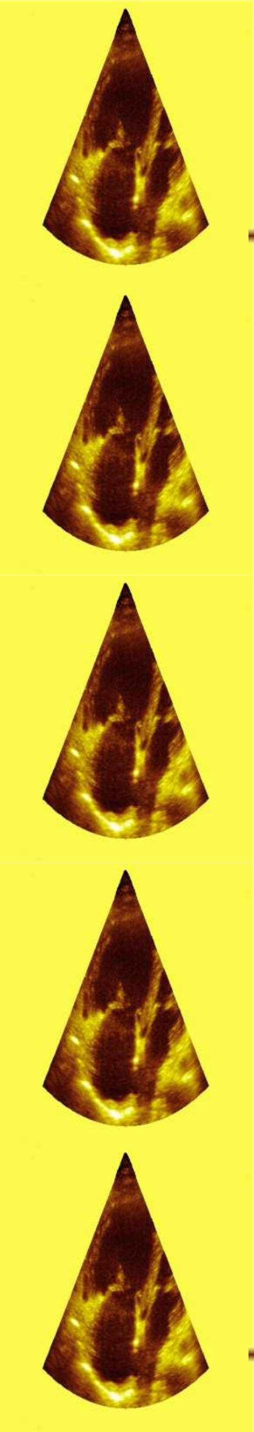


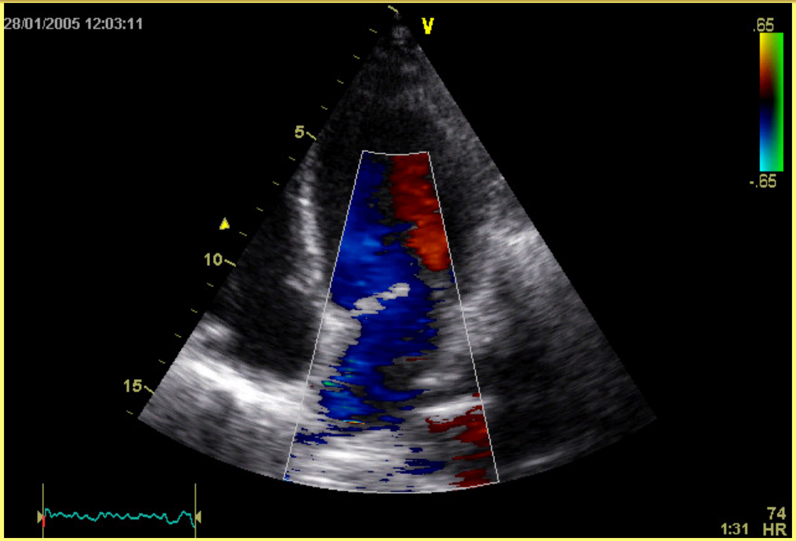
Les différentes techniques

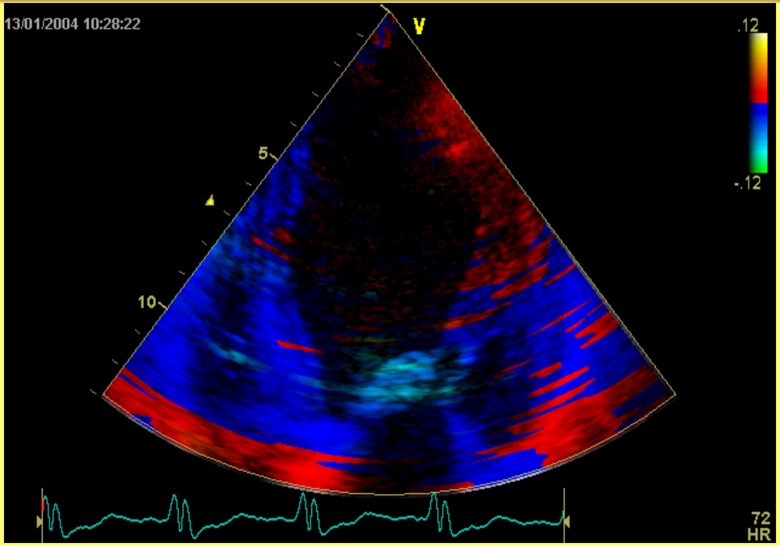
- Doppler
  - Vitesse de déplacement du sang ou des parois (DTI)
  - Plusieurs modes :
    - couleur (bleu : s'éloigne de la sonde, rouge : se rapproche de la sonde)
    - continu
    - pulsé

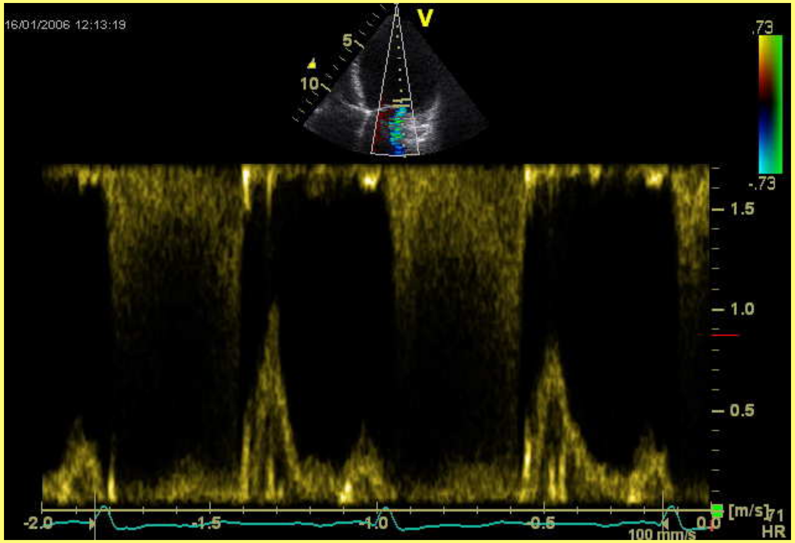


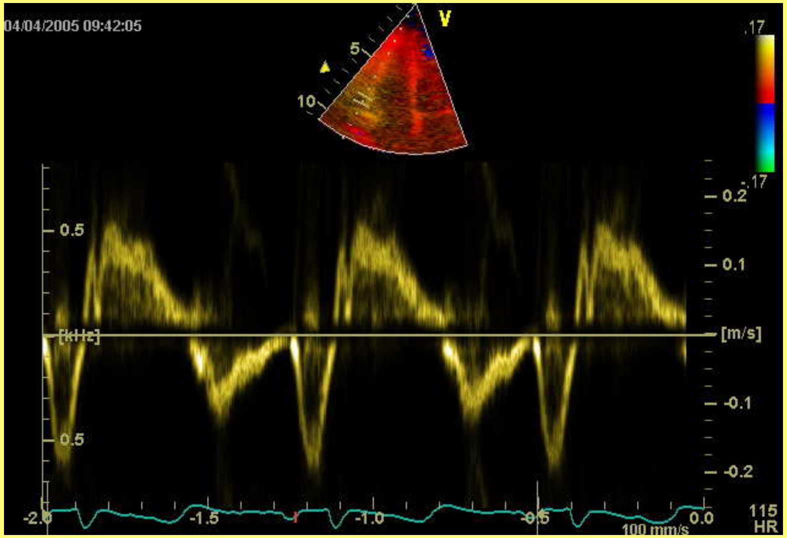
Les différentes techniques



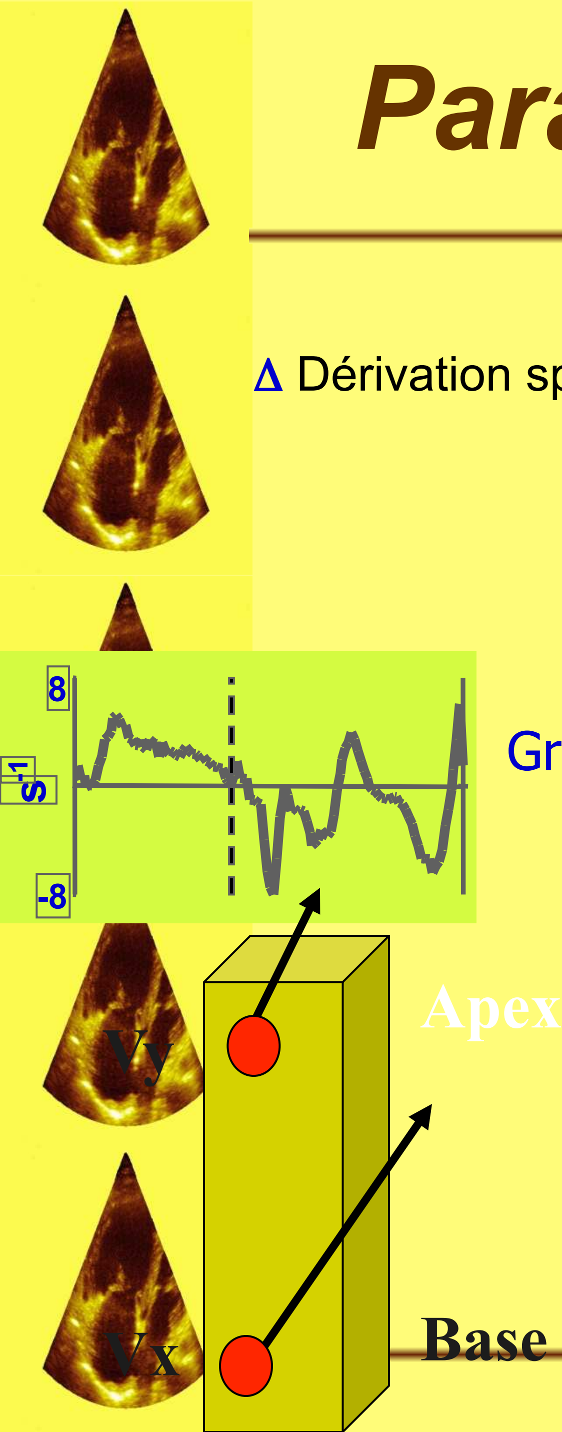




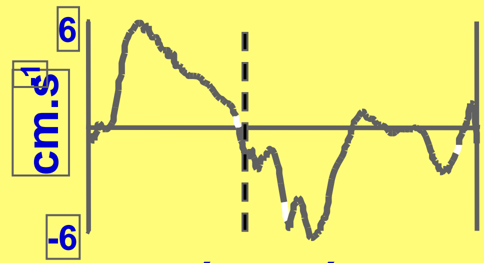




Paramètres dérivés du DTI



Δ Dérivation spatiale



∫ Intégration temporelle

Vélocités

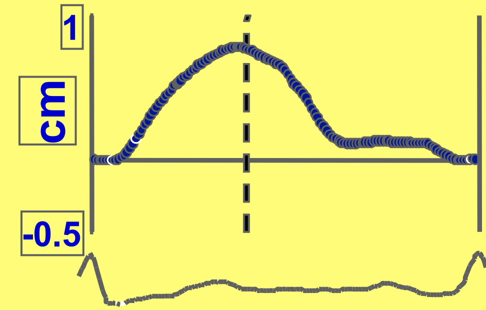
∫

Gradient de vitesse

Déplacement

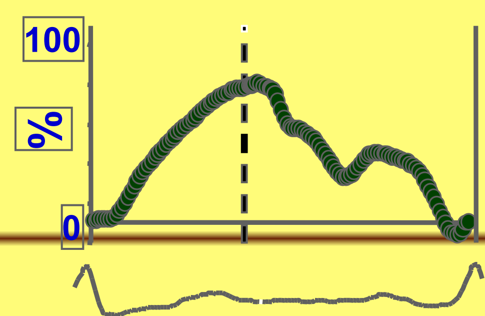
Strain Rate

Tissue Tracking



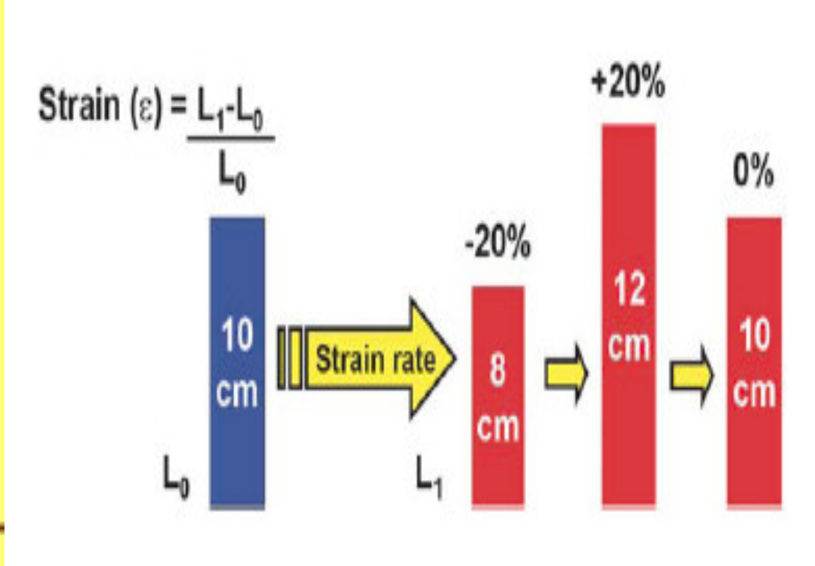
Déformation

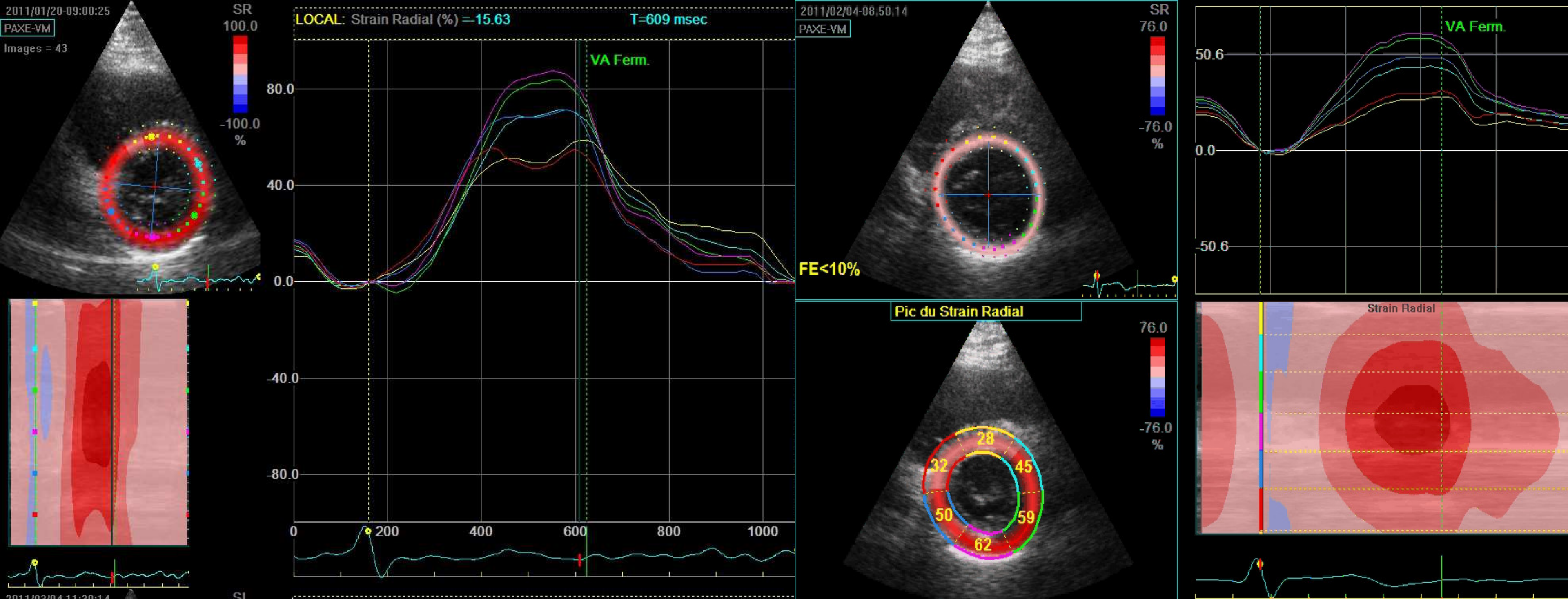
Strain

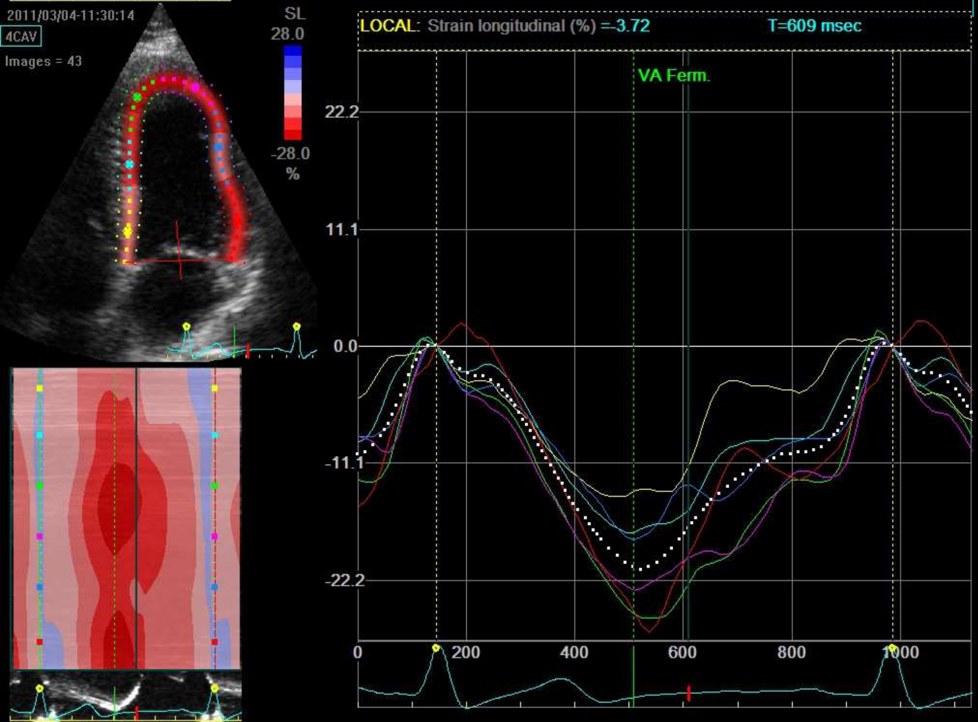


Strain (contrainte, tension)

- Strain (ε) = L1-L0/L0 en %
- Déformation relative d'un segment suite à l'application d'une force
- Fraction de raccourcissement d'une fibre myocardique





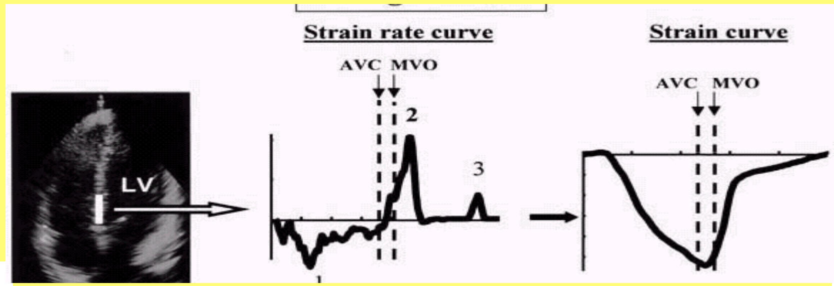


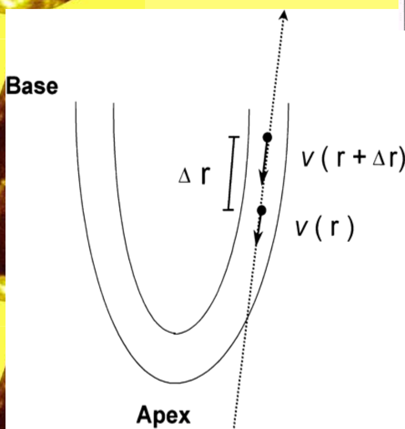
- L0 = TD donc
 strain longitudinal
négatif et
strain radial positif

Apport du DTI dans ses différentes modalités

	Vitesse	Amplitude
Déplacement (actif/passif)	DTI (cm/s)	TissueTracking (cm)
Déformation (active)	SR (s^{-1})	strain (%)

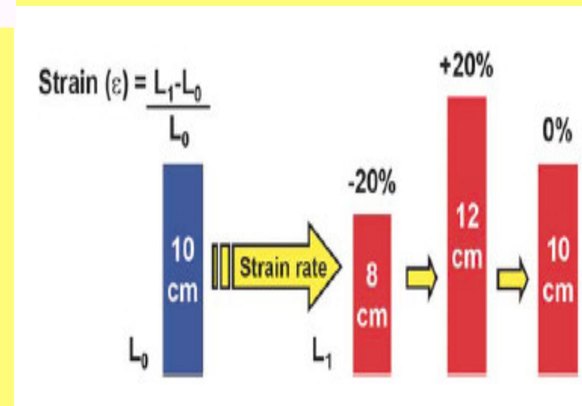
Strain rate et strain





SR = Δε / Δt

ε = ∫SR.dt



Dérivée par rapport au temps

Strain rate

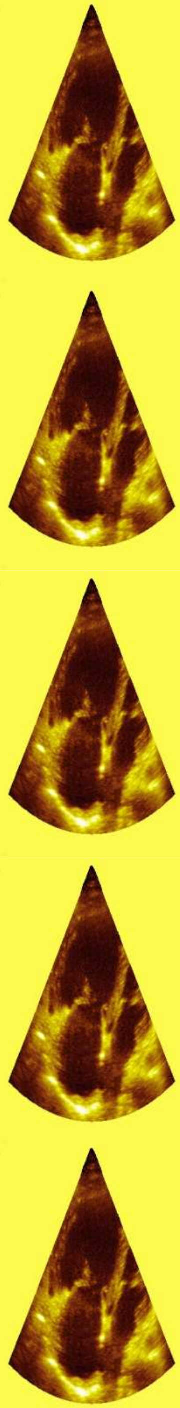
- = V(r+Δr)-V(r)/ Δr
- en s^{-1}
- Gdt de vitesse entre 2 pts
- Strain rate
- = V(r+Δr)-V(r)/ Δr
-

Intégrale par rapport au temps

Strain (ε)

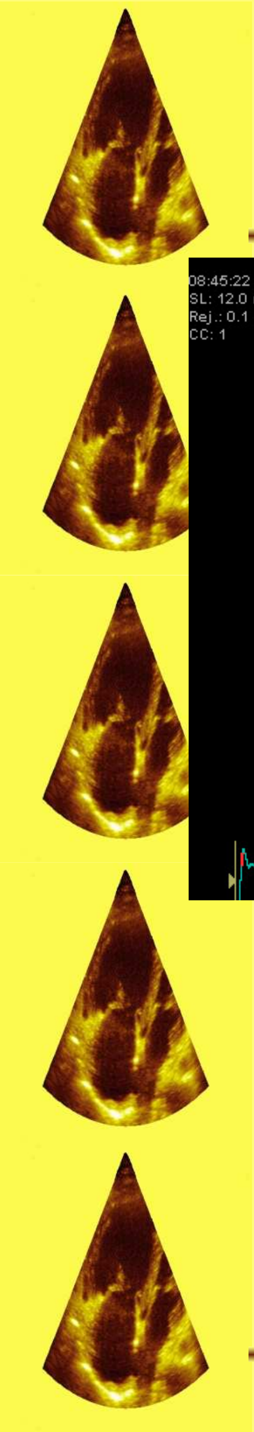
- = L1-L0/L0
- en %
- Déformation relative d'un segment suite à l'application d'une force

Strain (ε)

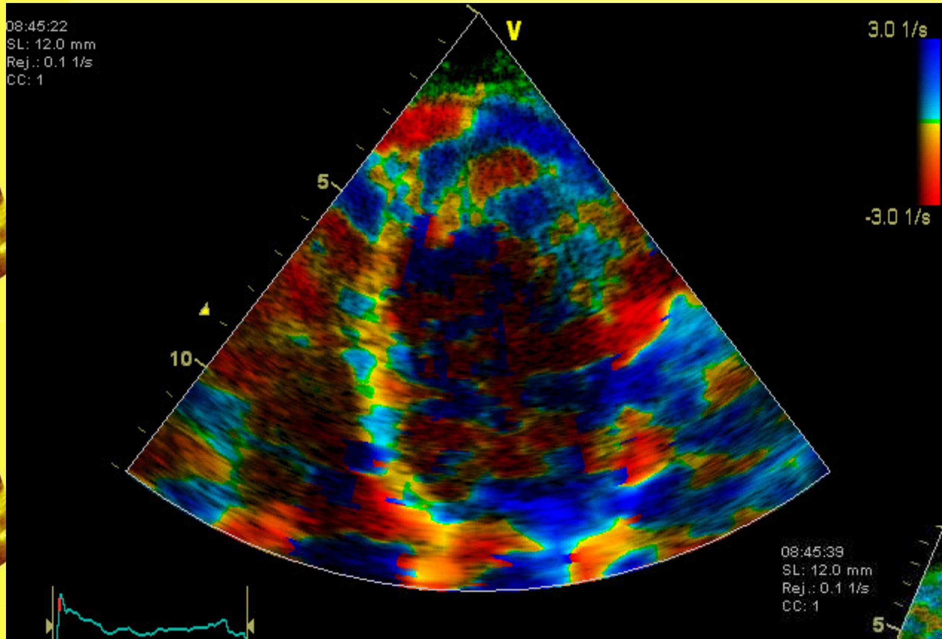


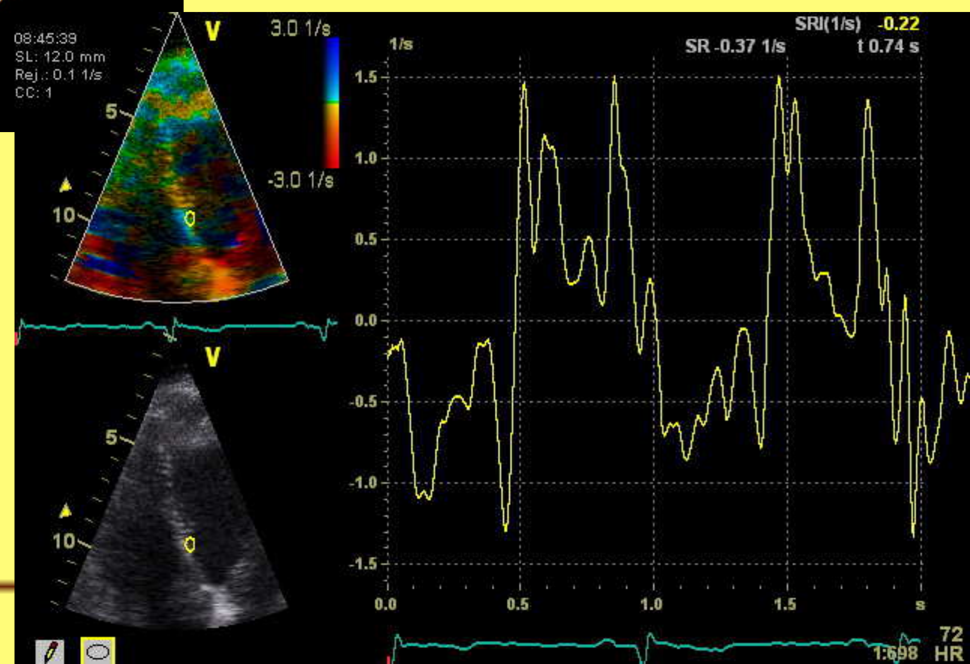
Strain et strain rate

- Paramètres de déformation myocardique
- Avantages :
  - permettent la différenciation entre mouvement actif et passif,
  - intéressants surtout chez ischémiques
- Inconvénients :
  - encore très expérimental,
  - nbs artefacts,
  - mesures longues,
  - opérateur-dépendants

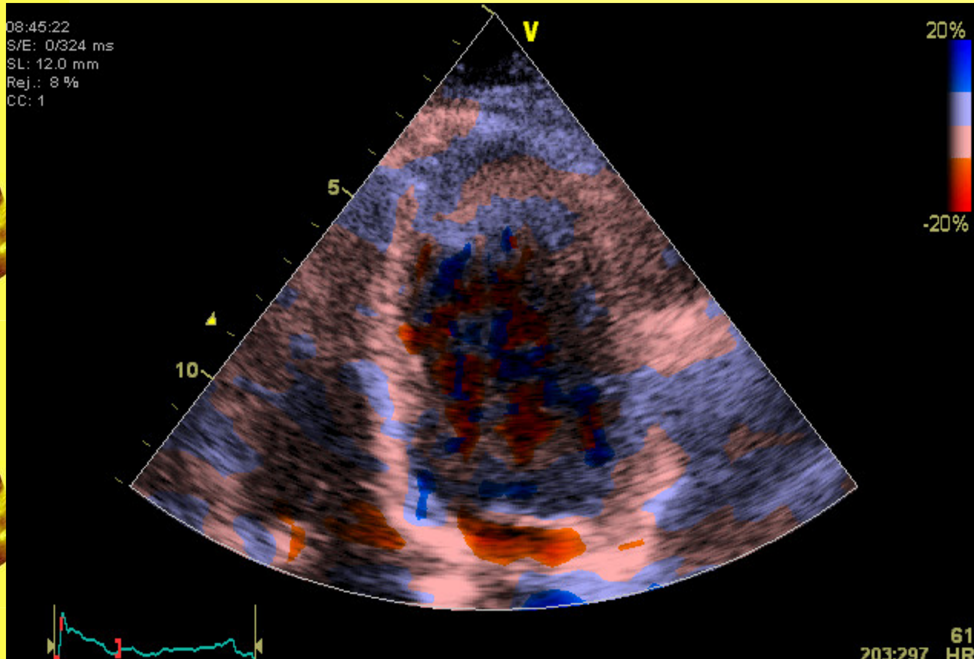


Strain rate

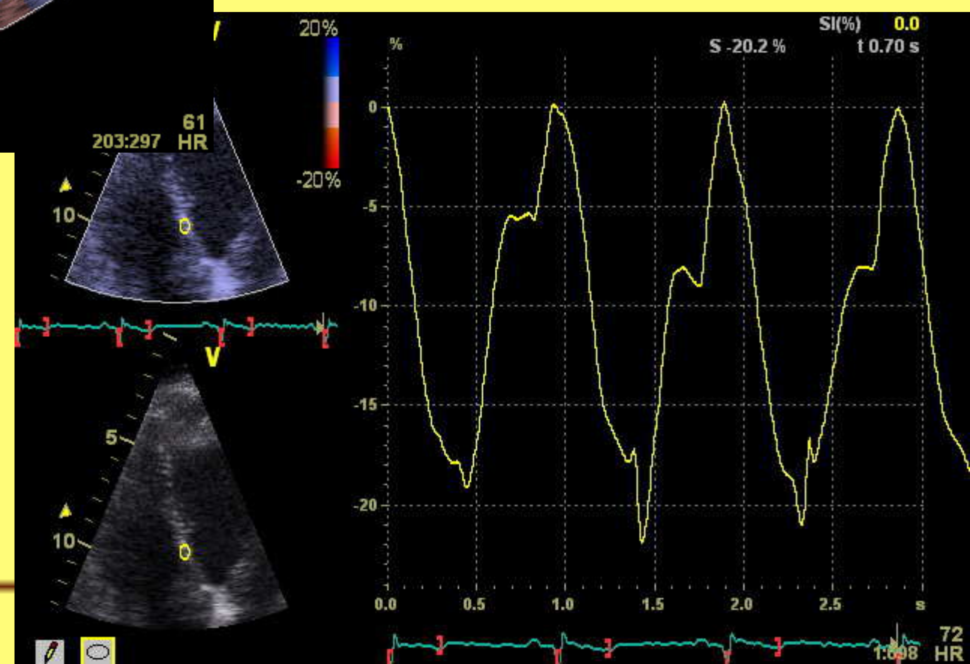

08:45:22
SL: 12.0 mm
Rej.: 0.1 1/s
CC: 1
V
3.0 1/s
-3.0 1/s
5
10


08:45:39
SL: 12.0 mm
Rej.: 0.1 1/s
CC: 1
V
3.0 1/s
-3.0 1/s
5
10
SRI(1/s) -0.22
SR -0.37 1/s
t 0.74 s
1/s
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0.0
0.5
1.0
1.5
s
72
HR

Strain

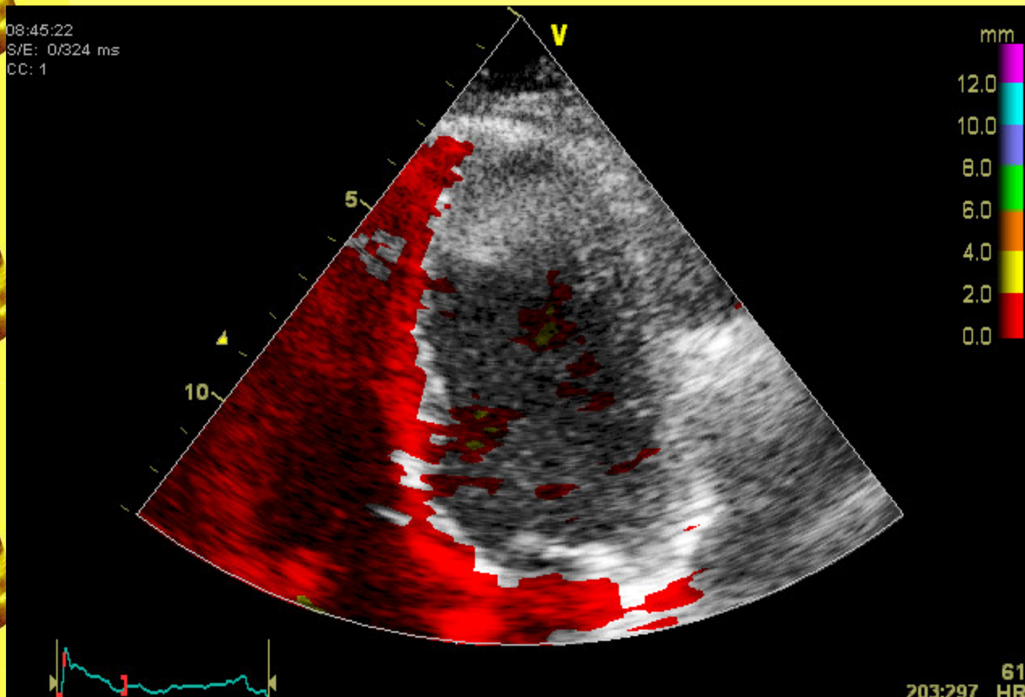


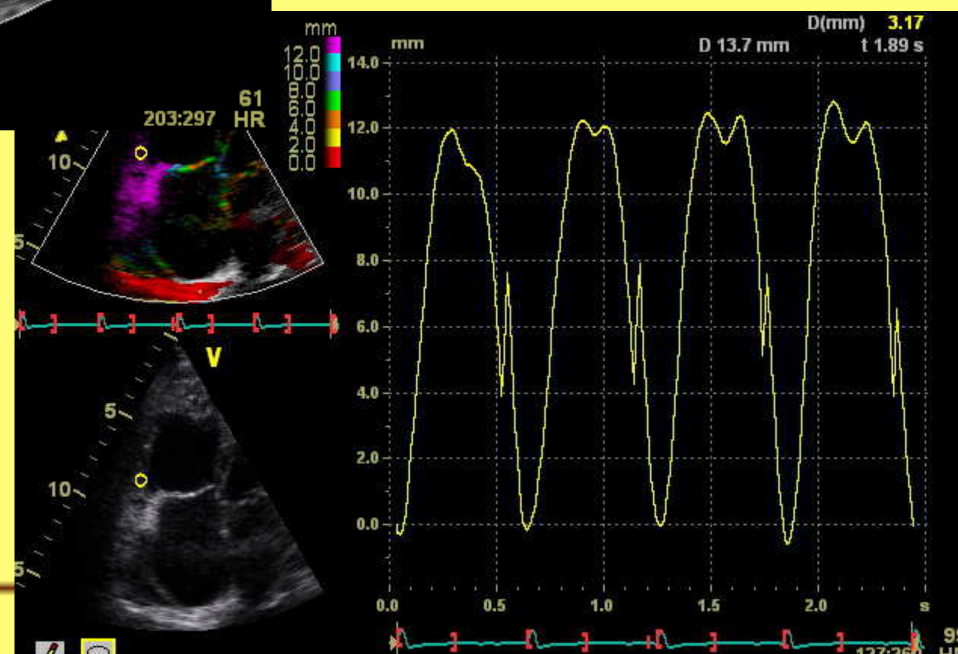
08:45:22
S/E: 0/324 ms
SL: 12.0 mm
Rej.: 8 %
CC: 1
V
20%
-20%
5
10



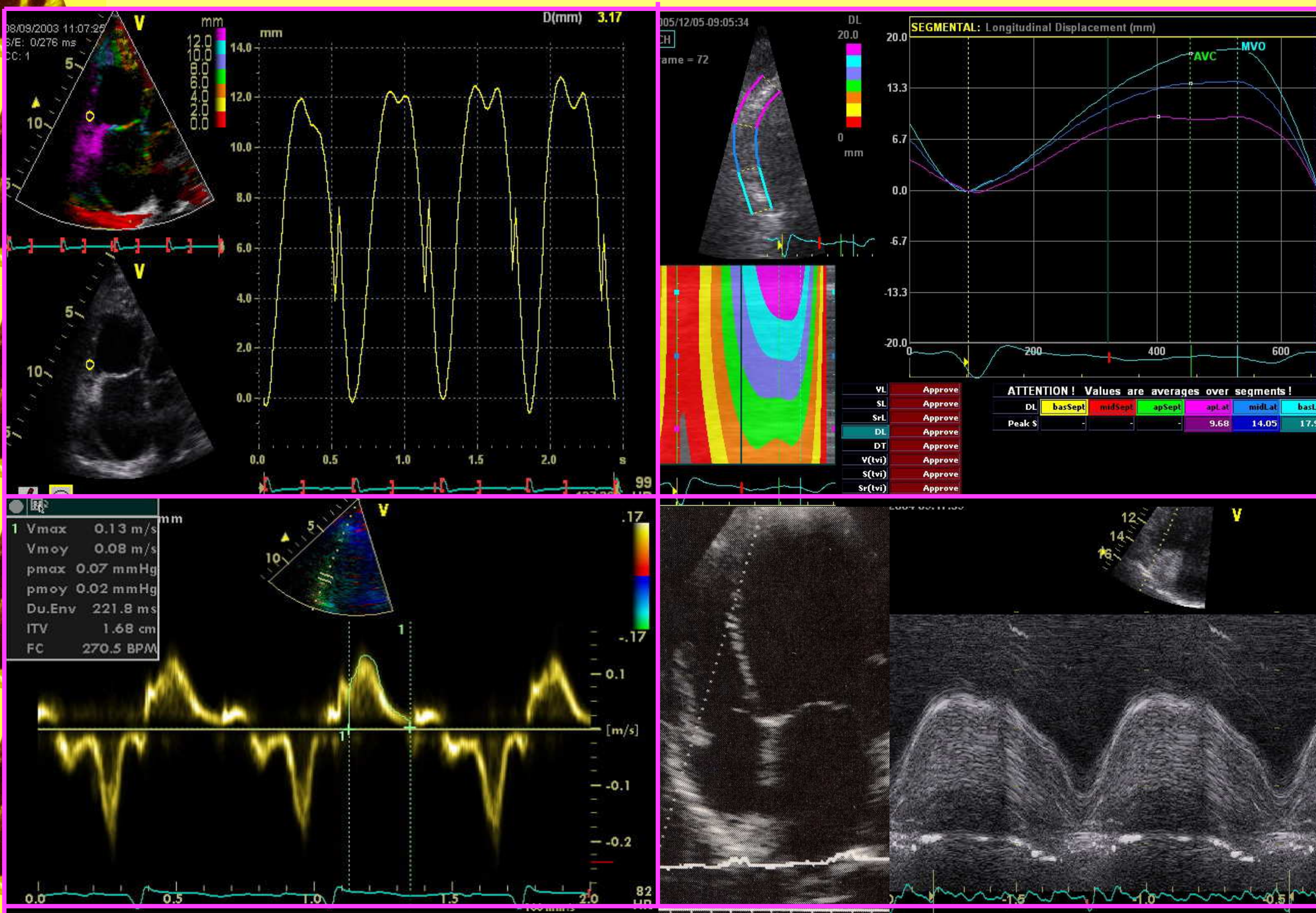
20%
-20%
61
203:297 HR
V
5
10
SI(%) 0.0
S -20.2 %
t 0.70 s
%
0
-5
-10
-15
-20
0.0
0.5
1.0
1.5
2.0
2.5
s
72
HR

Tissue tracking



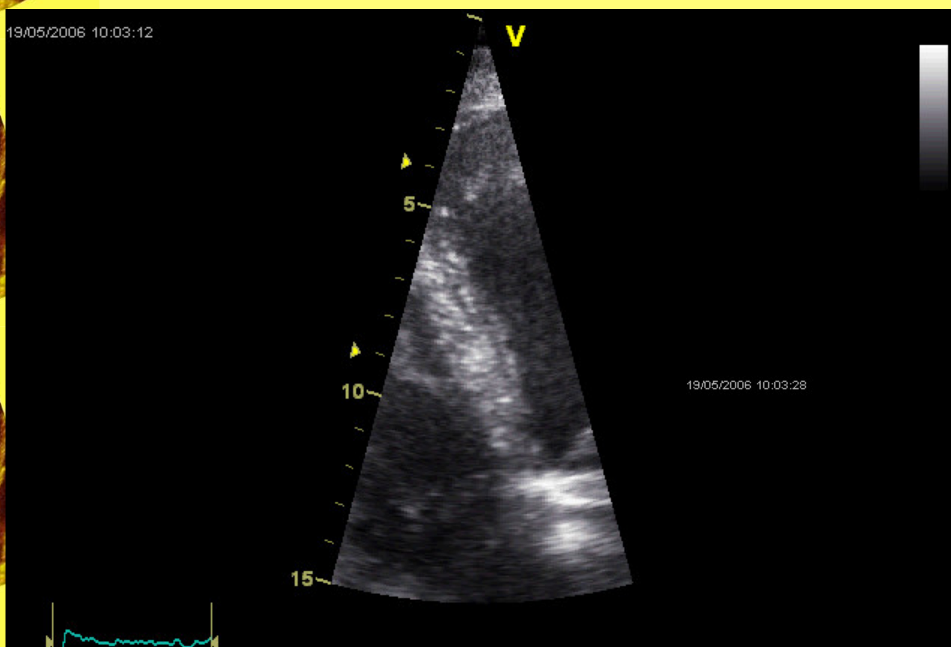


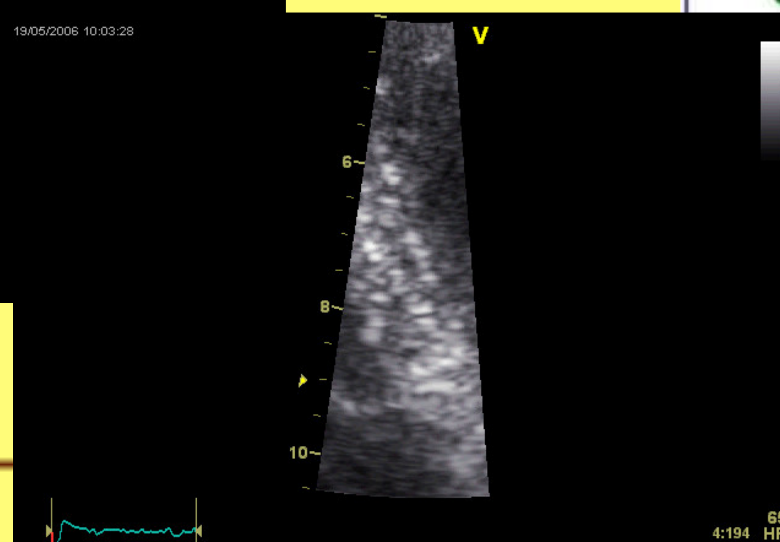
Déplacement myocardique

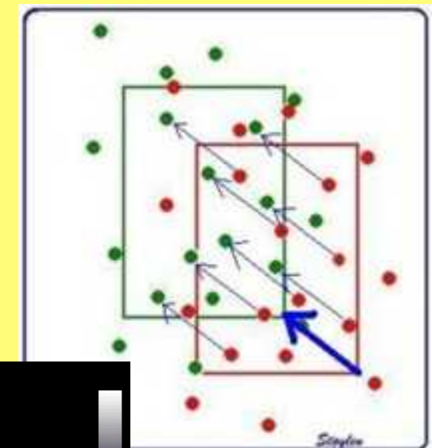


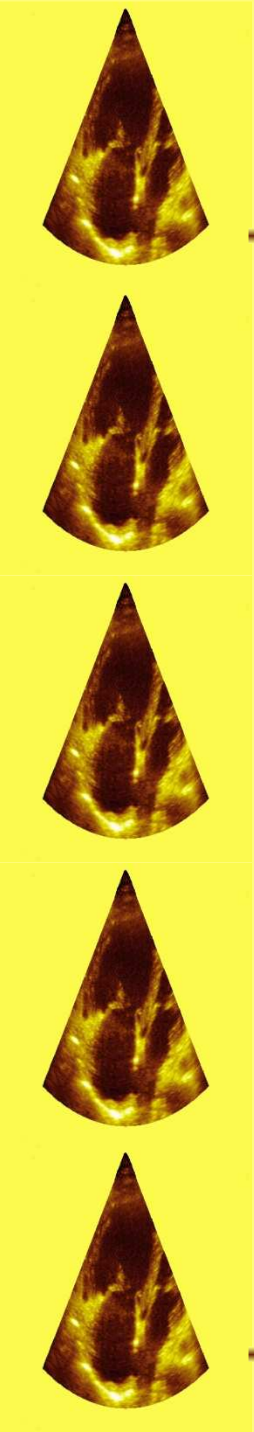
2D speckle tracking

- Alias 2D strain
- Analyse la déformation myocardique à partir de l'image brute 2D





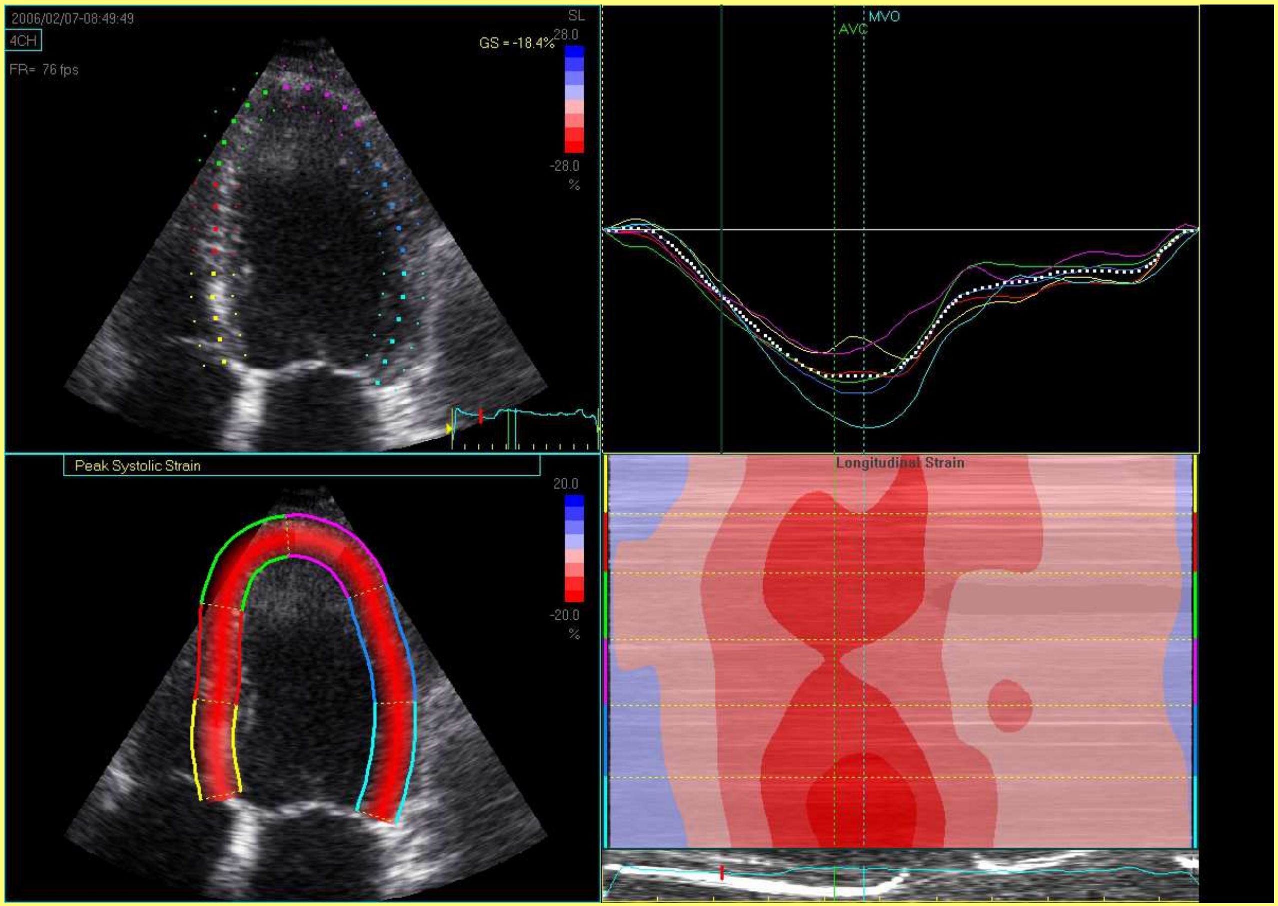




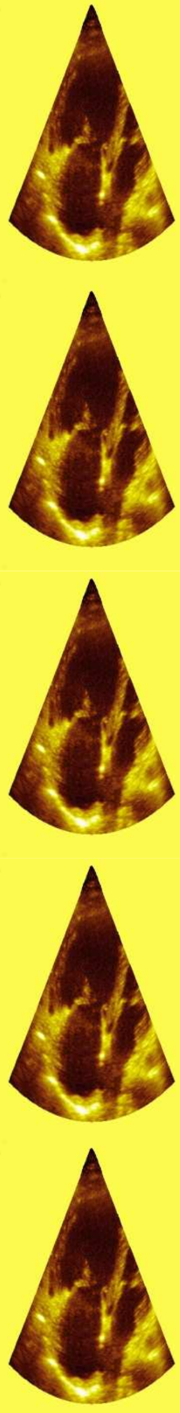
2D speckle tracking

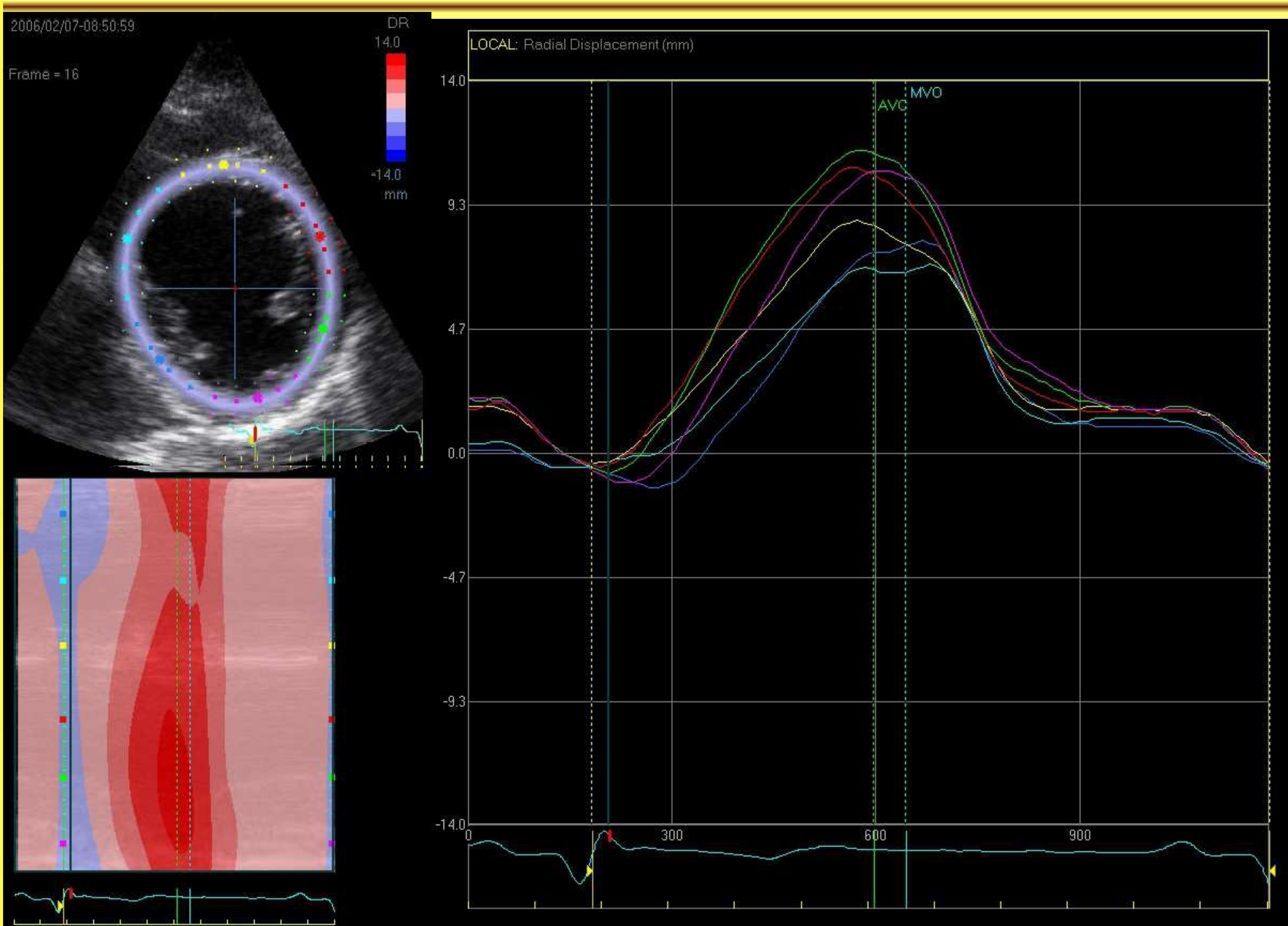
- Meilleure reproductibilité que le DTI car indépendante de l'angle
- Etudie la contraction myocardique dans ses 3 dimensions : radiale, longitudinale, et circonférentielle dans un seul plan en 2D, mais dans l’espace en 3D
- Moins sensible aux déplacements passifs

2D speckle tracking



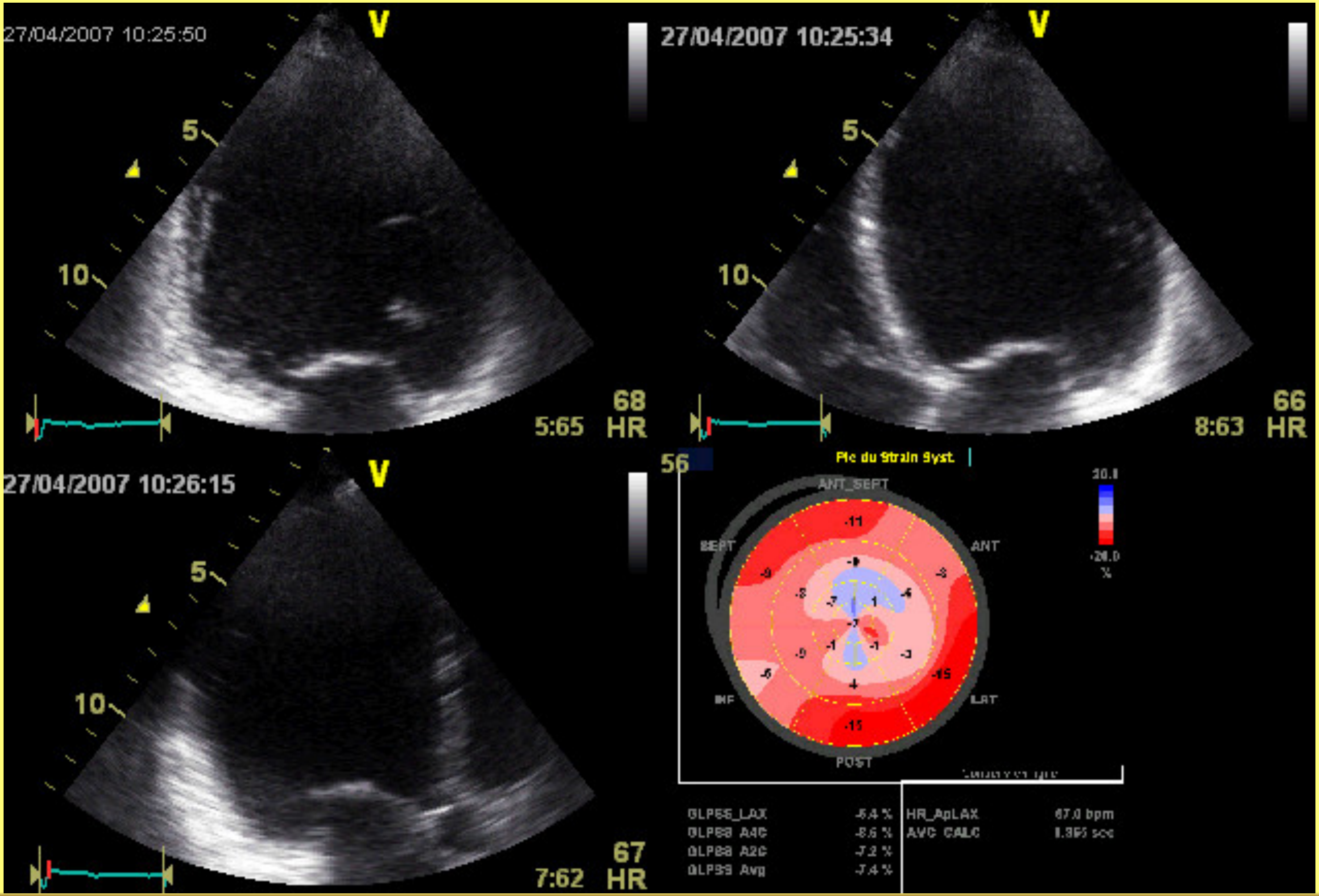
2D speckle tracking



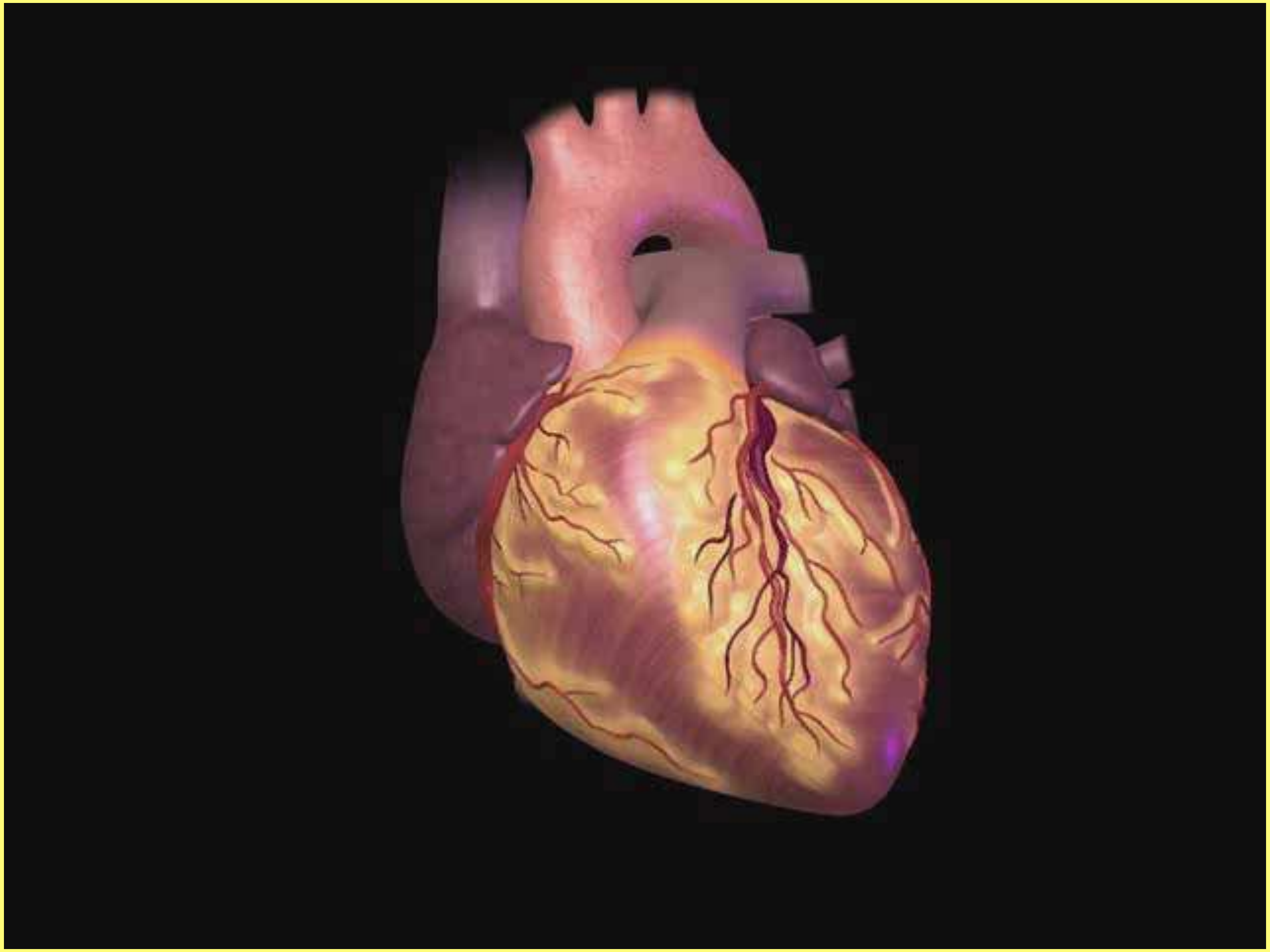


Le strain global longitudinal

- Valeur normale > 20%

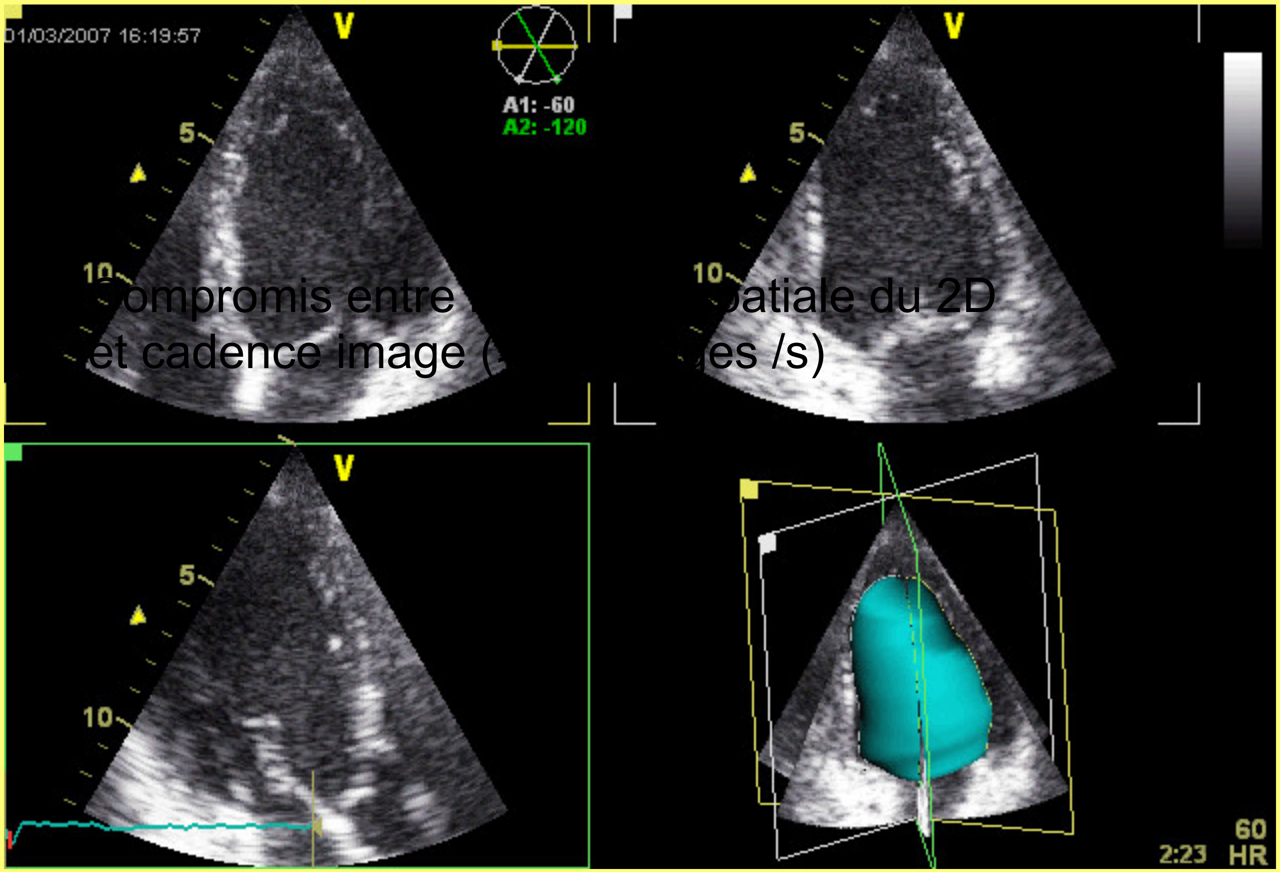


Le mode triplan

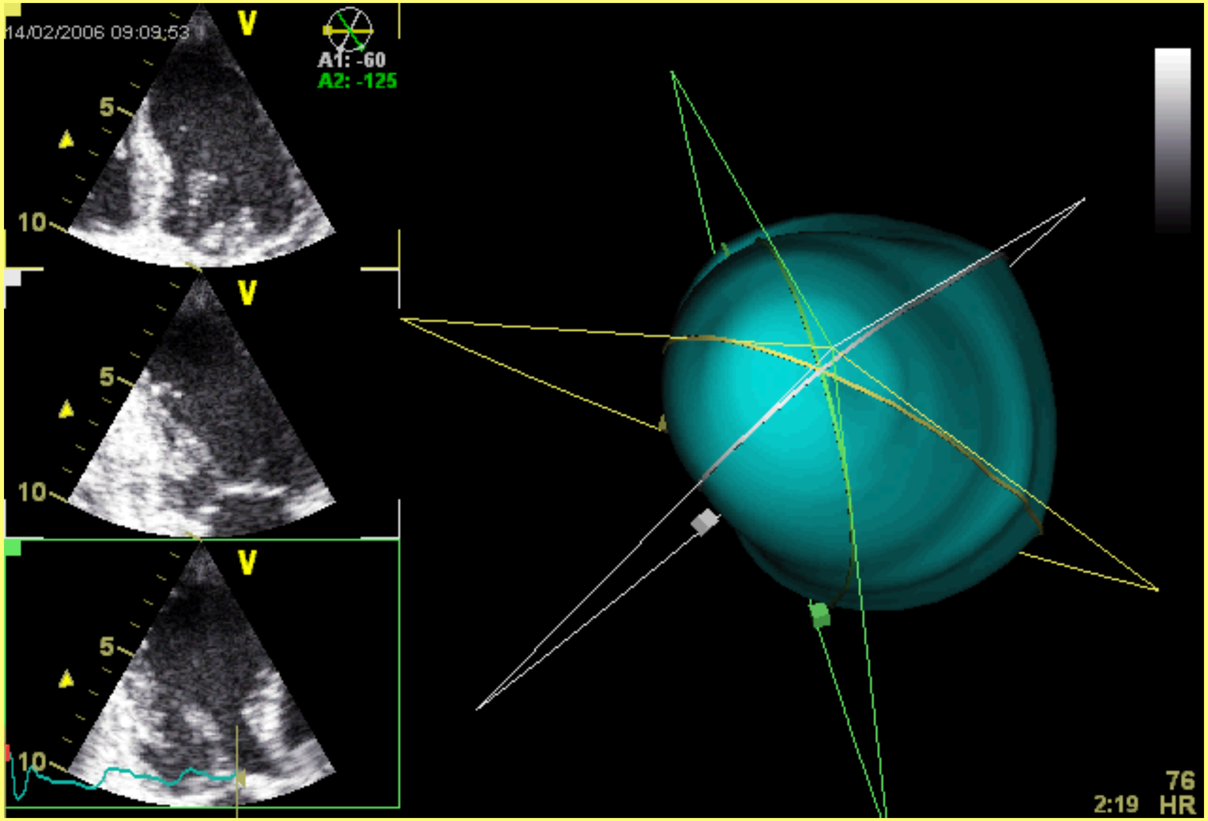


Les différentes techniques

- Echo 3D mode triplan

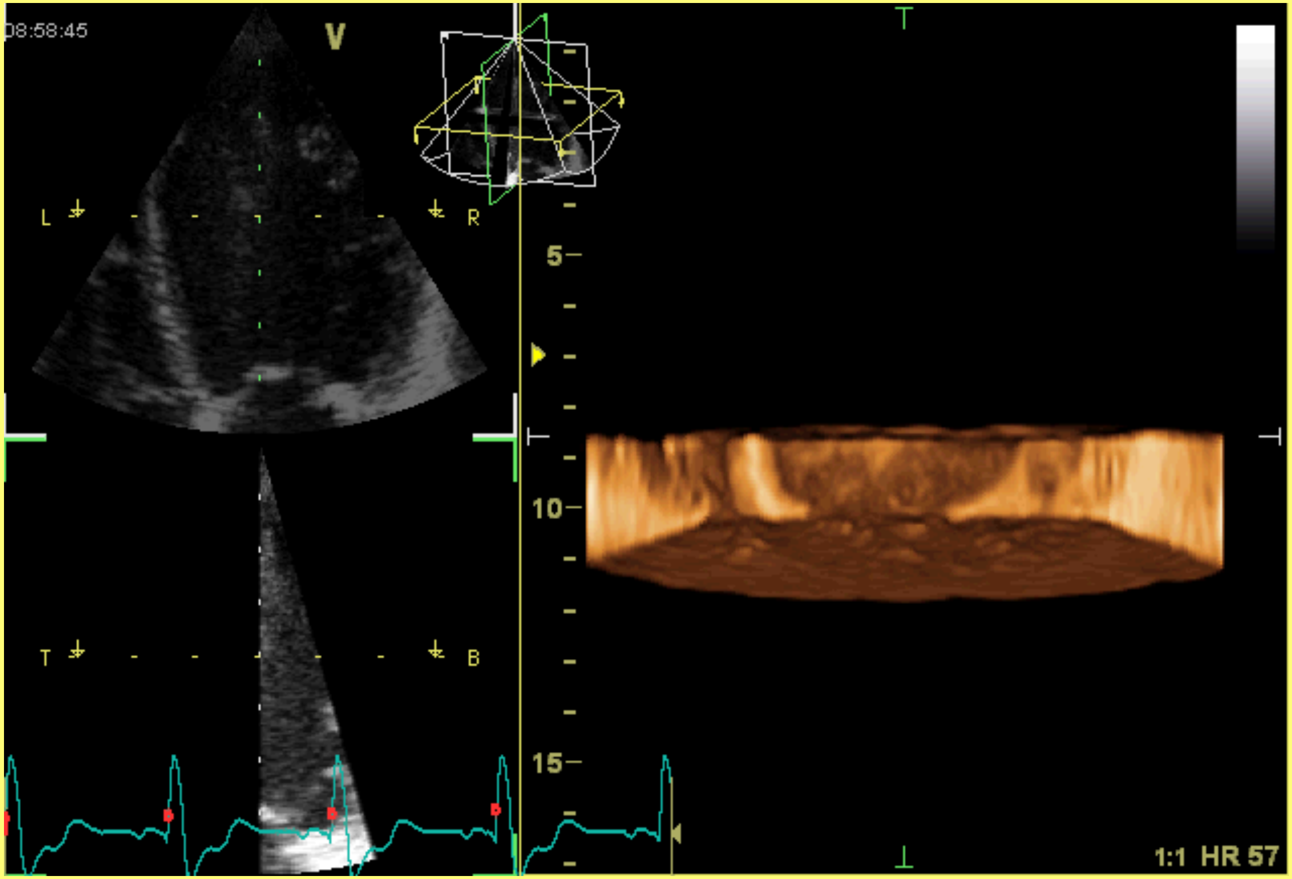


FE VG en triplan



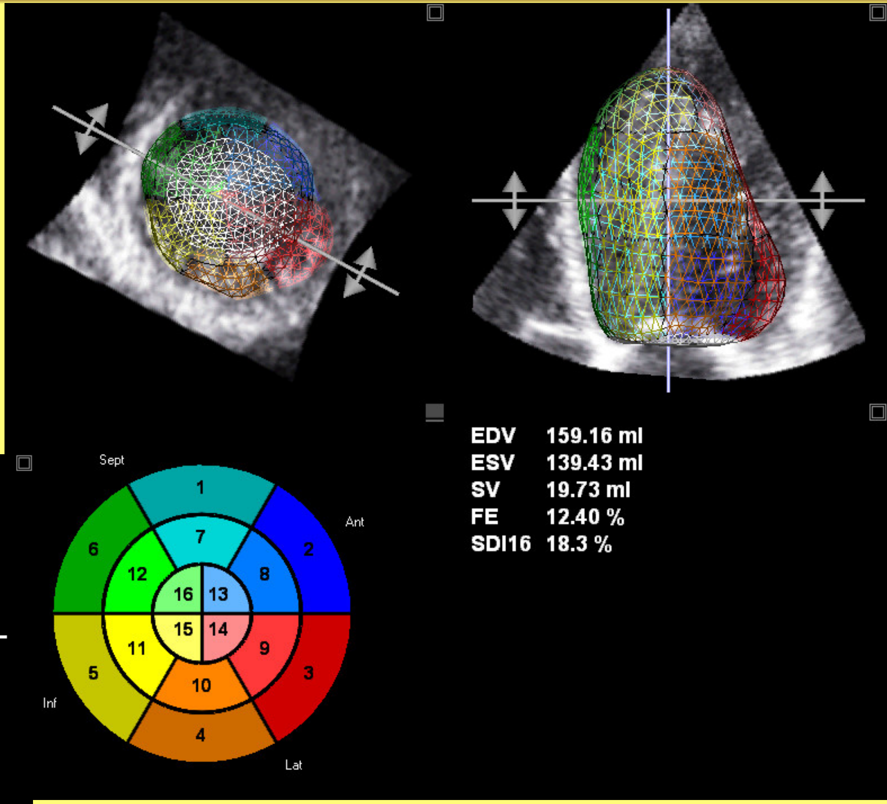
Les différentes techniques

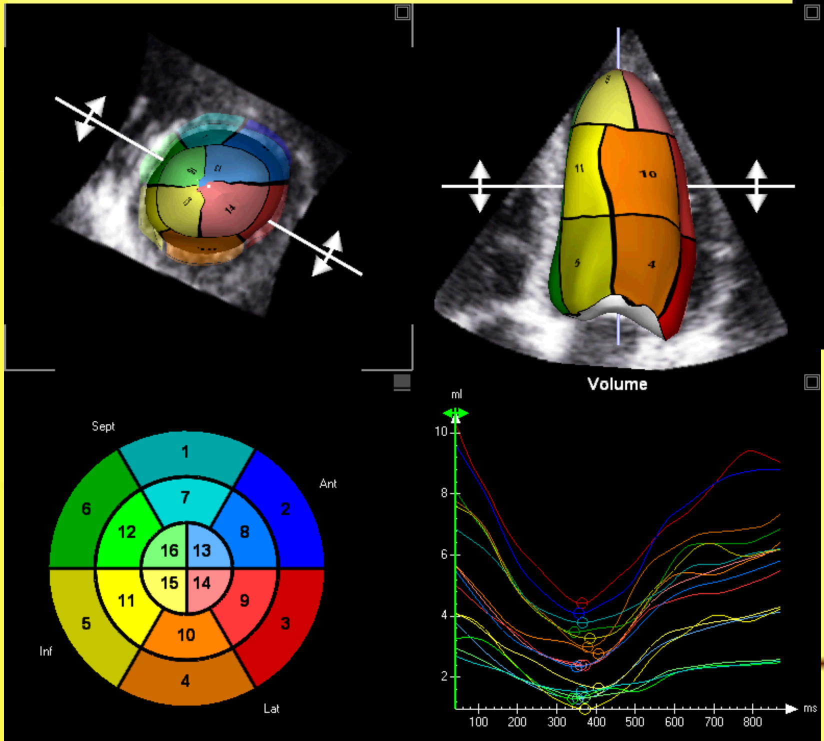
- Echo 3D/4D



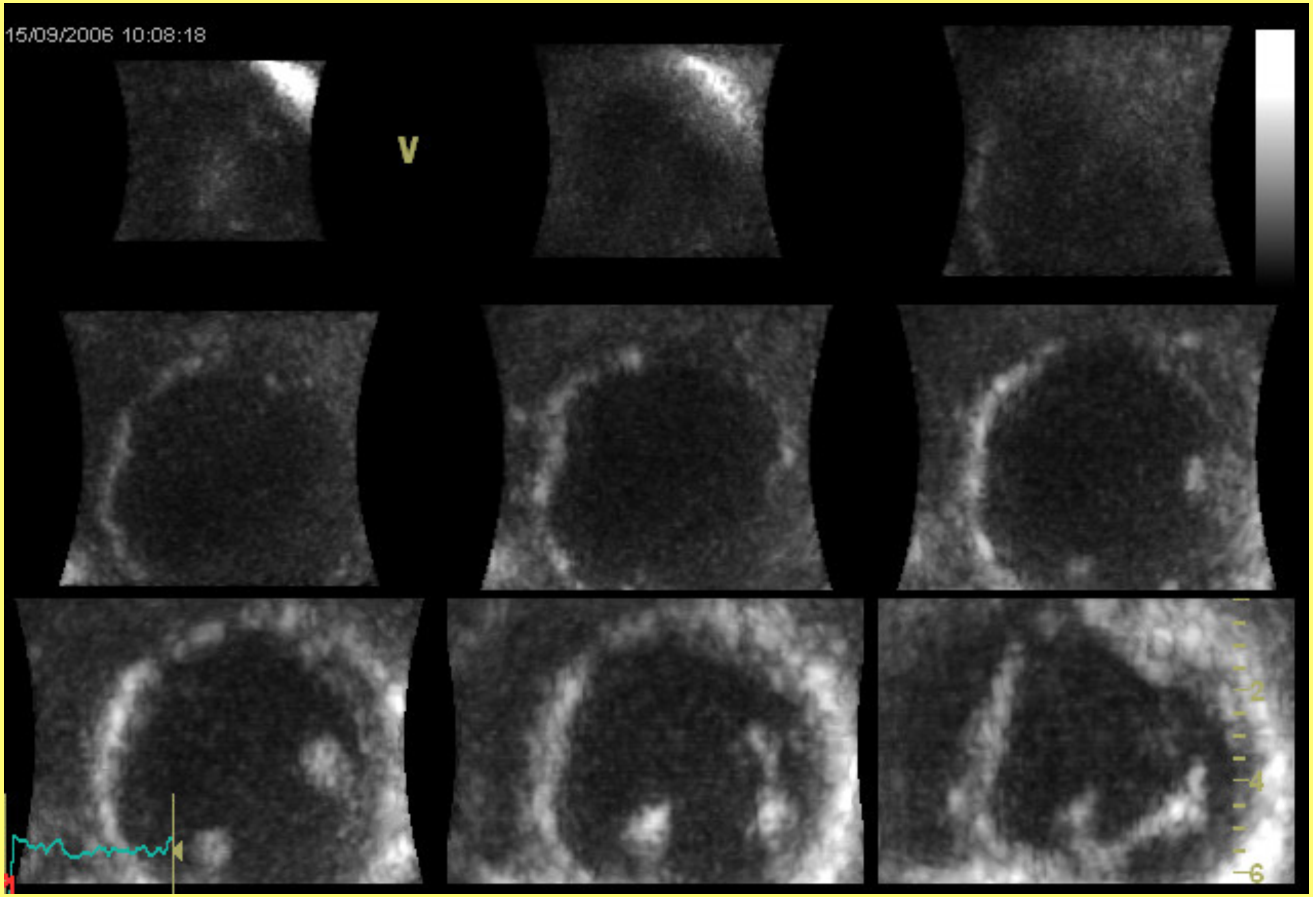
Les différentes techniques

- Echo 3D/4D



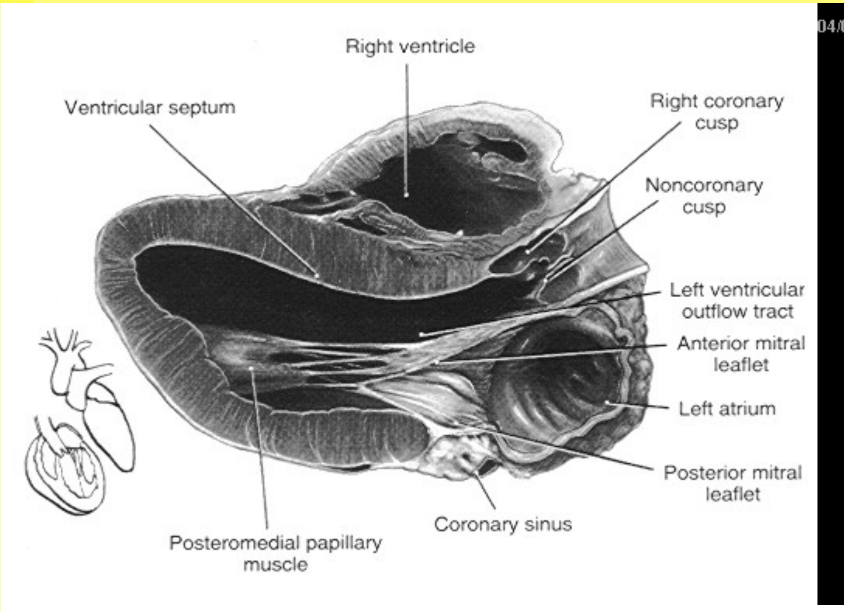


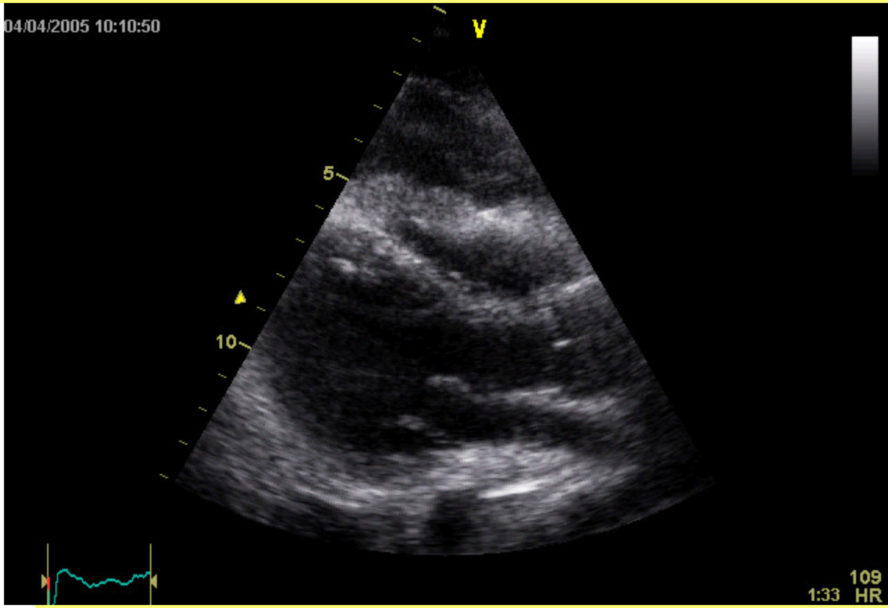
L'écho 4D

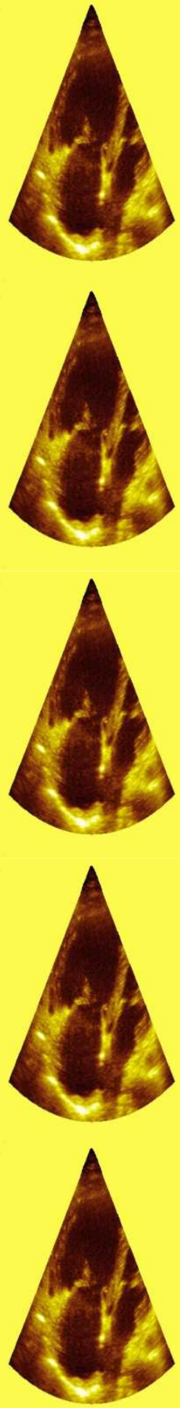


Les voies d'examen (ETT)

- La voie parasternale
  - Grand axe

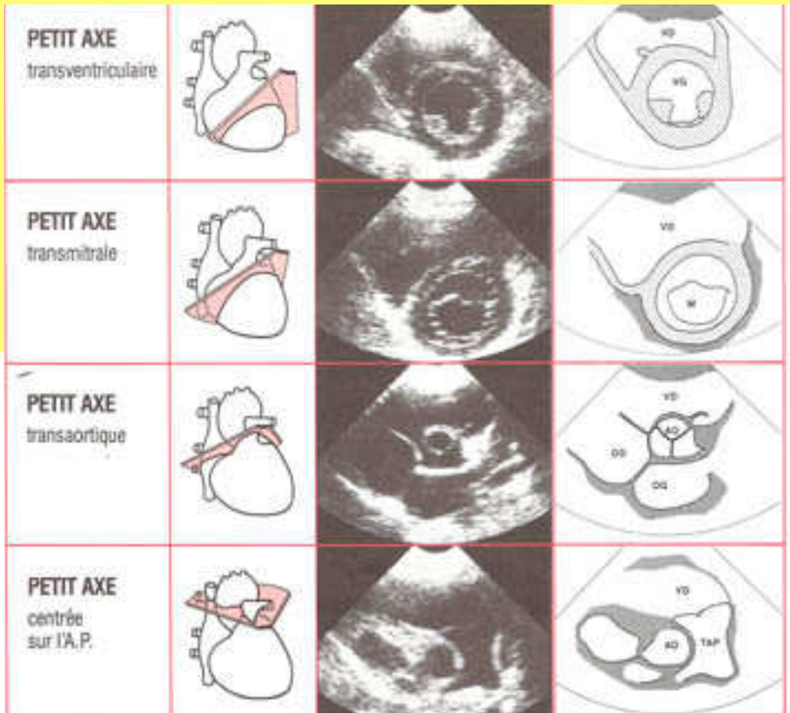


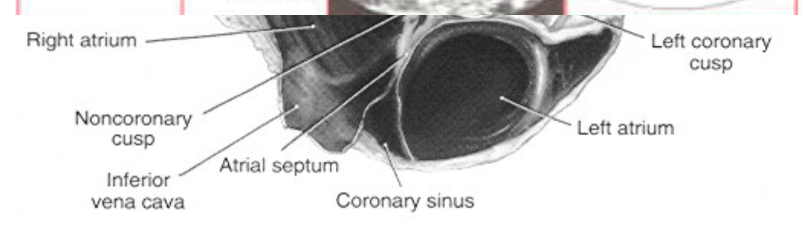


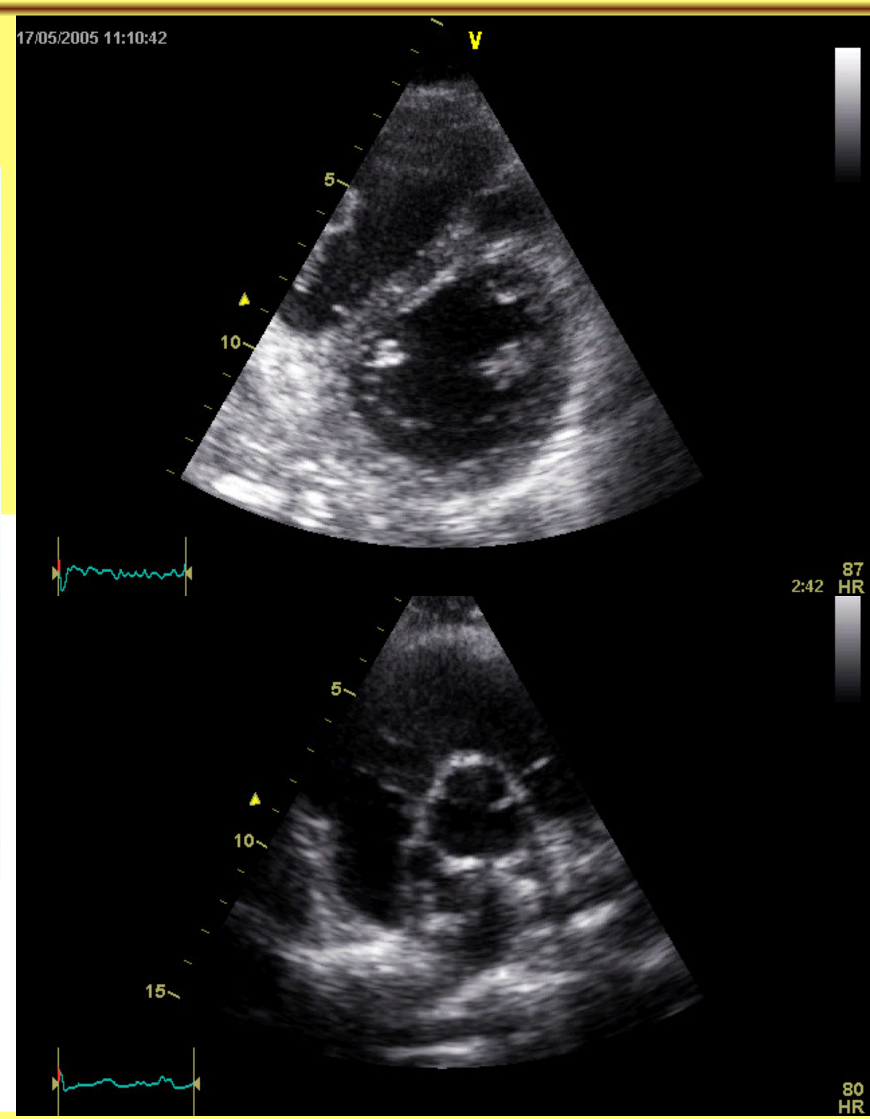


Les voies d'examen

- La voie parasternale
  - Petit axe

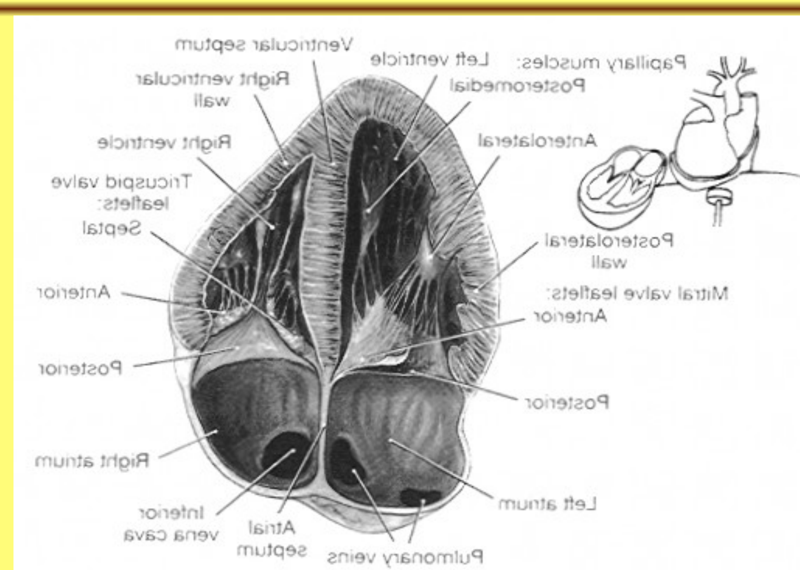


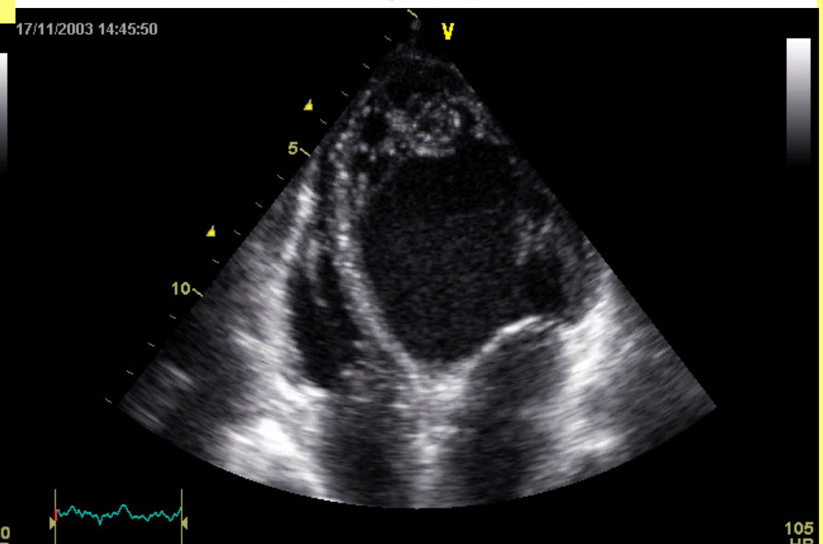




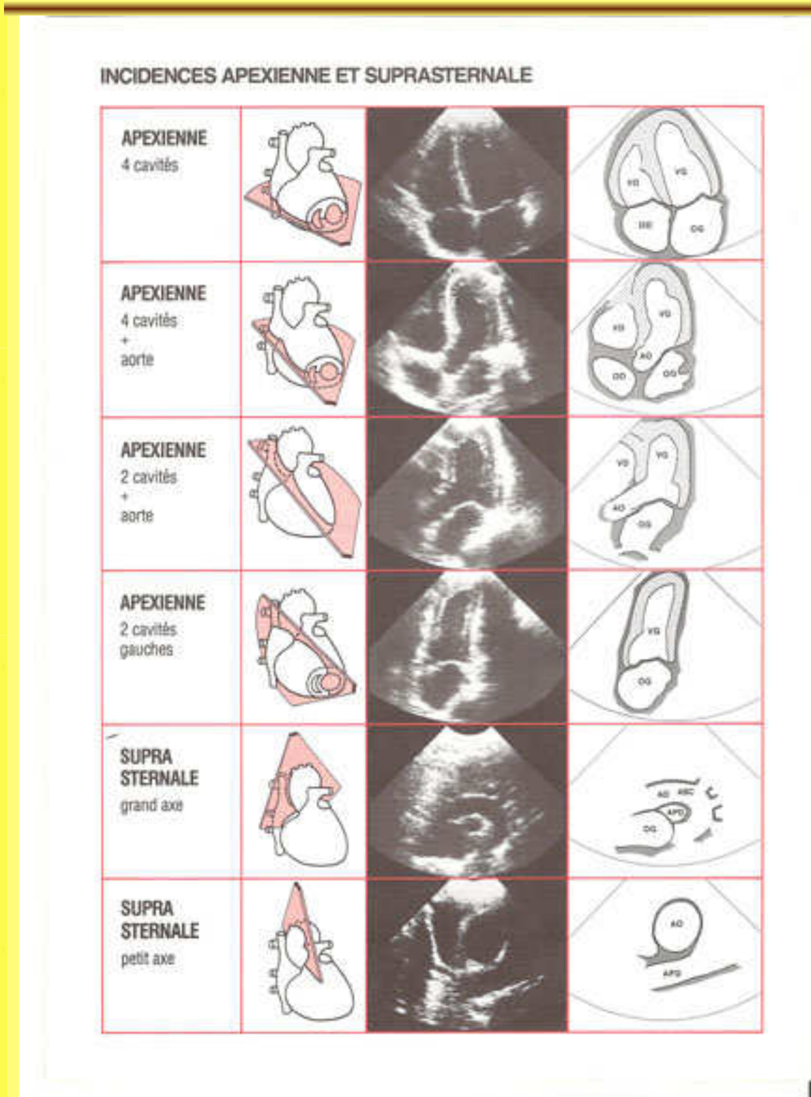
Les voies d'examen

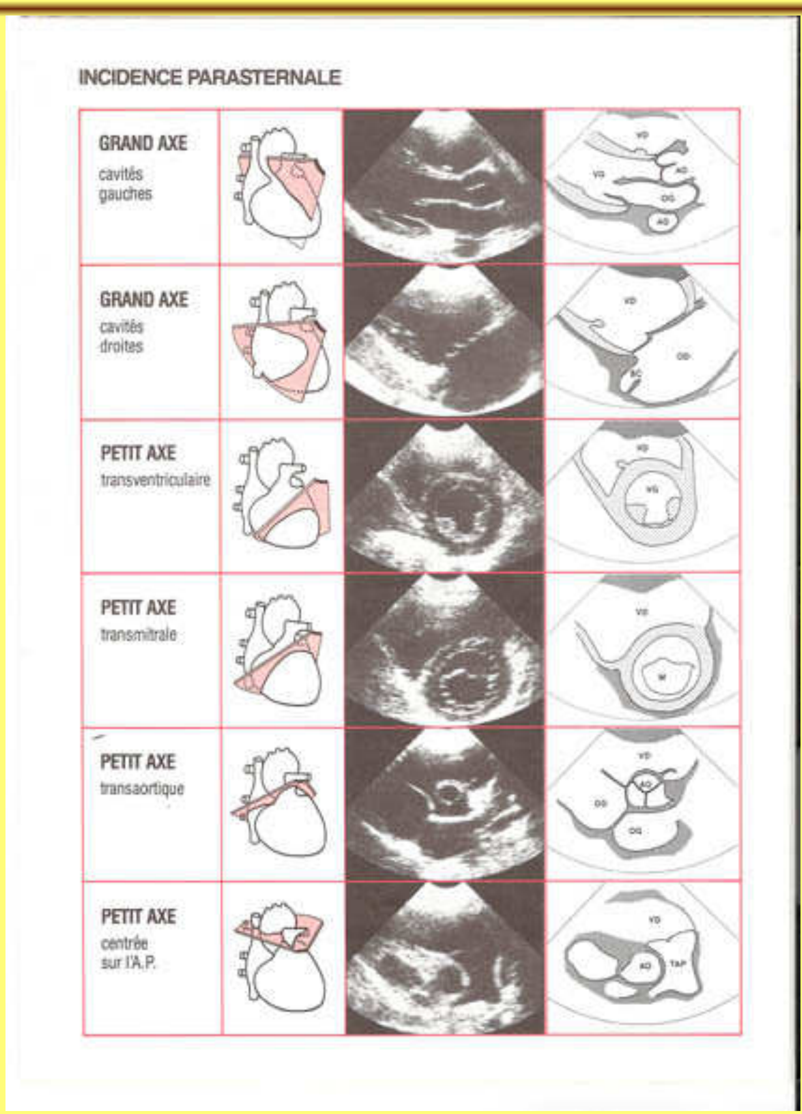
- La voie apicale
  - 4 Cavités
  - 2 et 3 cavités
- Les autres voies
  - Sous costale
  - Supra sternale





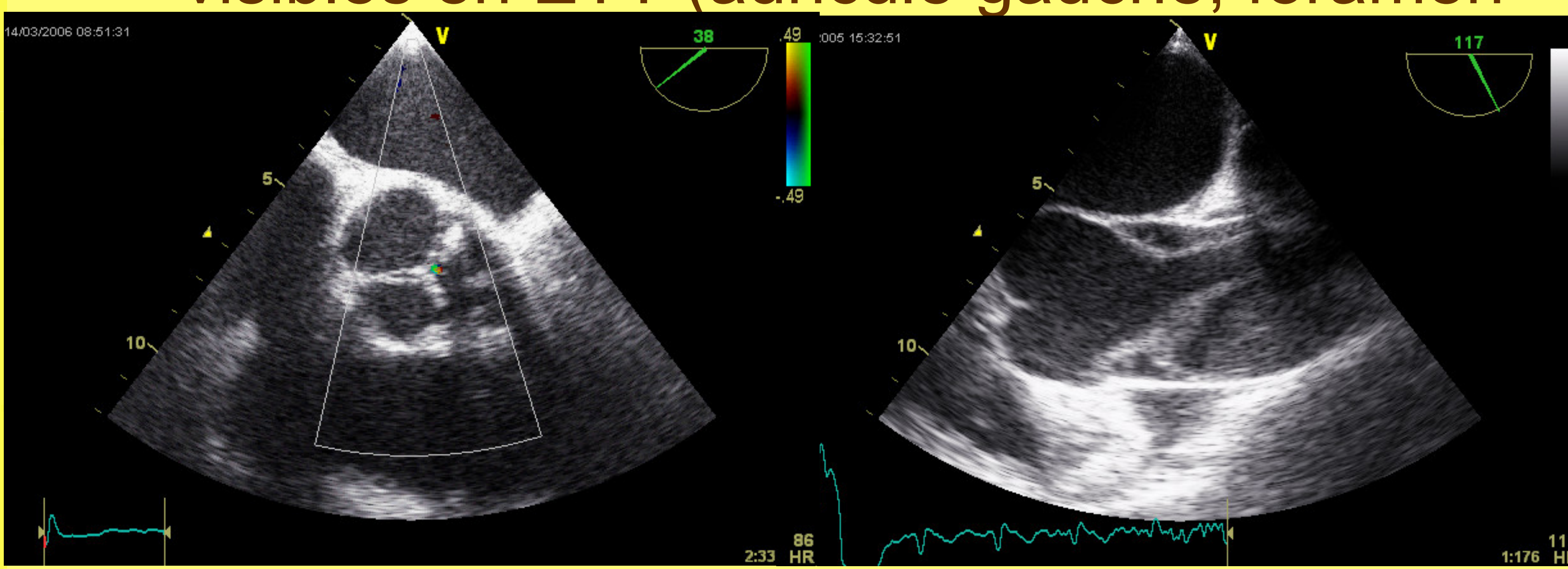
Nombreuses incidences

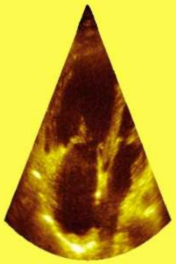
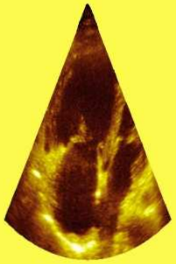
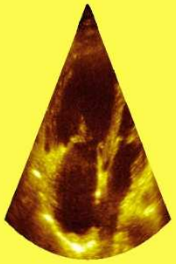
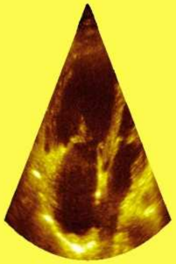
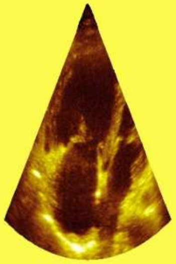




Les voies d'examen

- La voie transoesophagienne
  - Surtout utile pour la morphologie (valves + +)
  - Accès à certaines zones invisibles ou peu visibles en ETT (auricule gauche, foramen

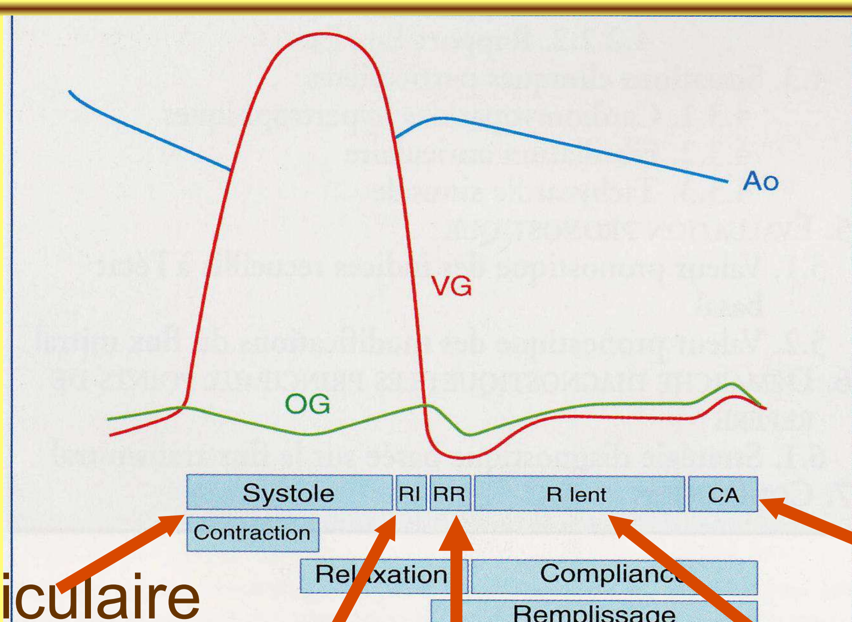


La fonction ventriculaire gauche

- La fonction systolique
  - La morphologie et la cinétique du VG
  - La fraction d'éjection VG
    - (VTD-VTS)/VTD
    - Valeur normale > 55%
  - Le débit cardiaque
- La fonction diastolique = précharge
  - Le flux mitral
  - Les pressions de remplissage
- La post-charge

Fonction ventriculaire



Systole ventriculaire

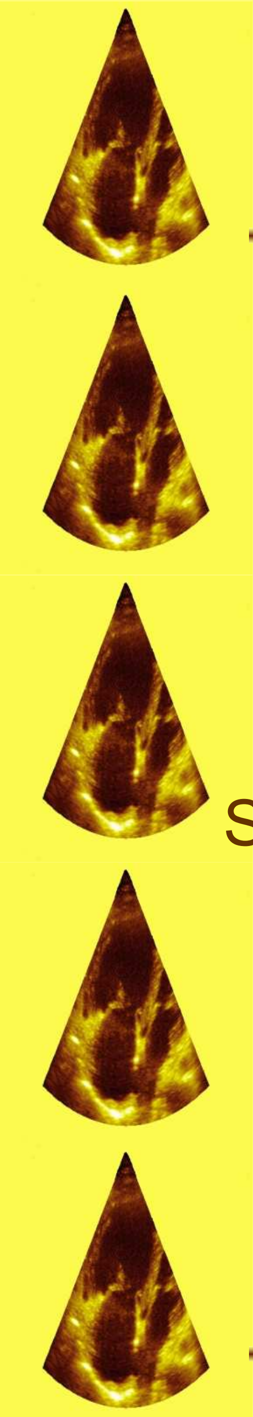
4- Systole auriculaire (15 - 20%)

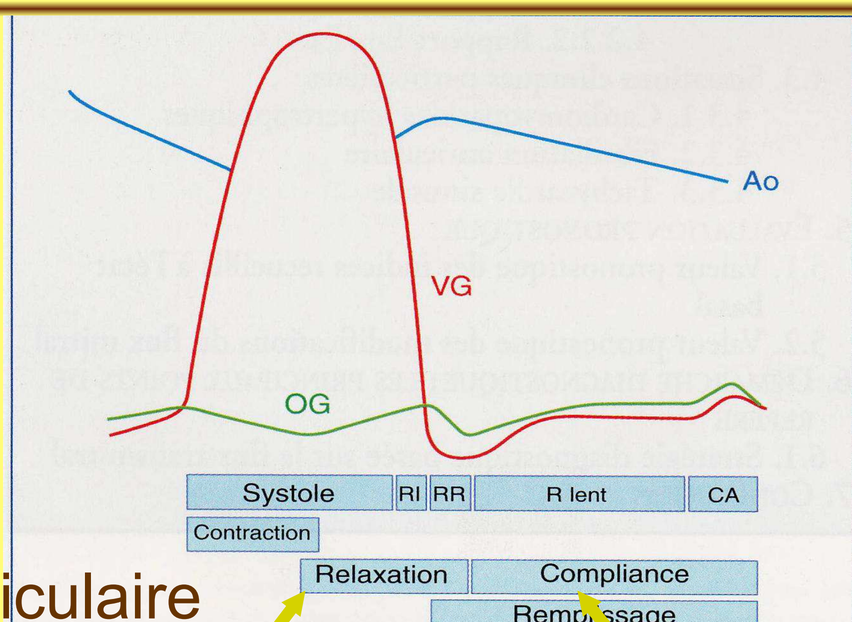
1- Relaxation isovolumétrique

2- Remplissage rapide (70 - 80%)

3- Remplissage lent (diastasis, <5%

Fonction ventriculaire





Systole ventriculaire

4- Systole auriculaire (15 - 20%)

1- Relaxation isovol

2- Remplissage rapide (70 - 80%)

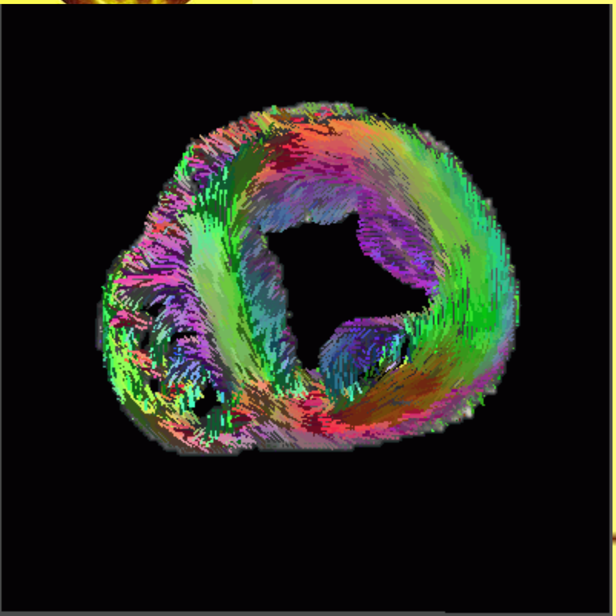
3-Remplissage lent (diastasis: <5%)

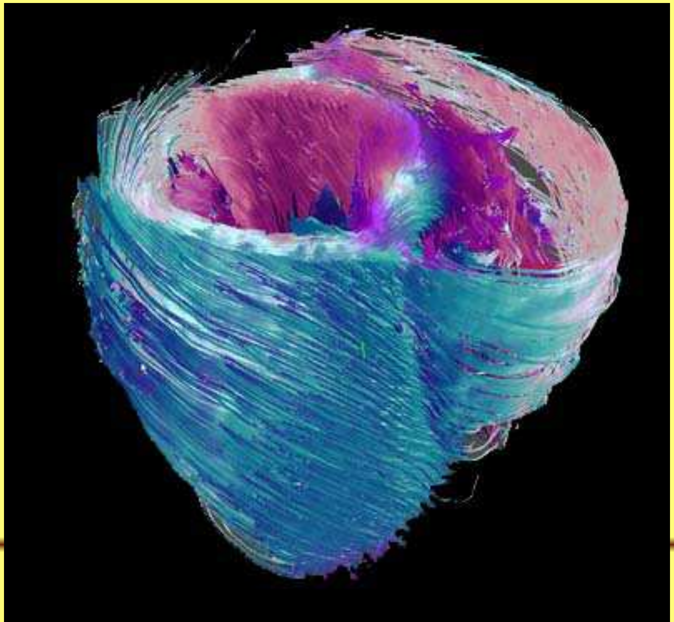
1- Phénomène actif (débute en systole)

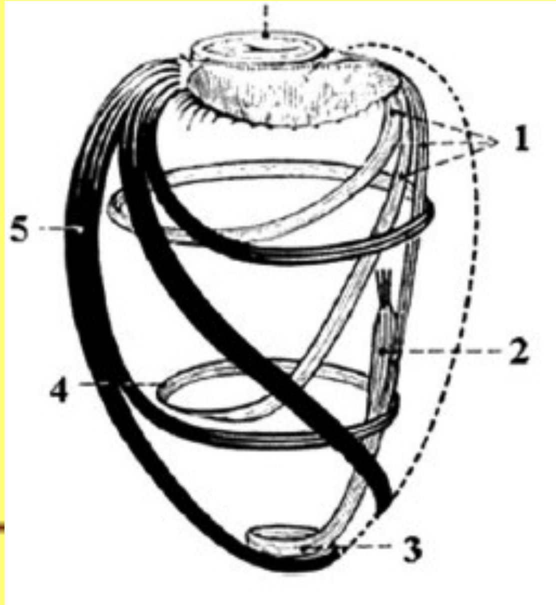
2- Phénomène passif: Propriétés visco-élastiques du myocarde

Les fibres myocardiques

- Orientation en 2 hélices d'orientations opposées
  - Endocarde : longitudinale vers la Dte
  - Médiane : circonférentielle
  - Épicarde : longitudinale vers la Gche







Les fibres myocardiques

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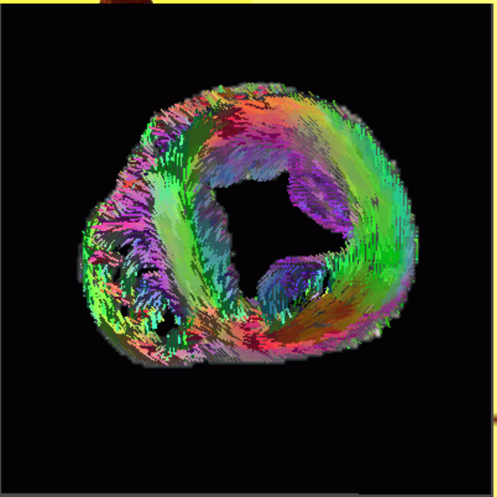
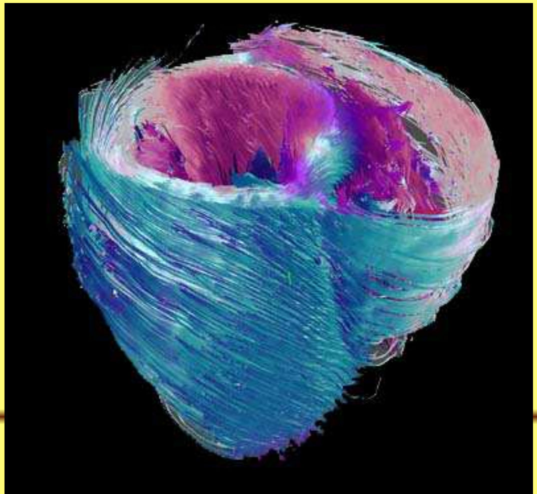
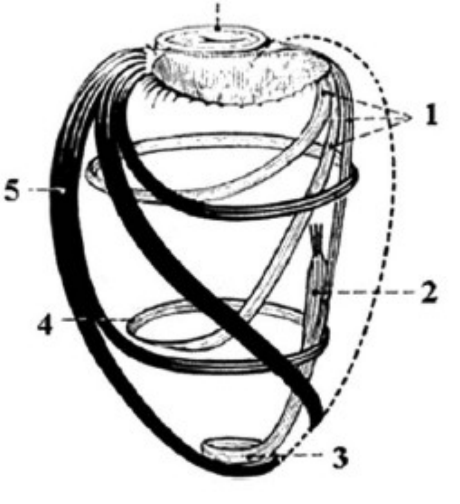
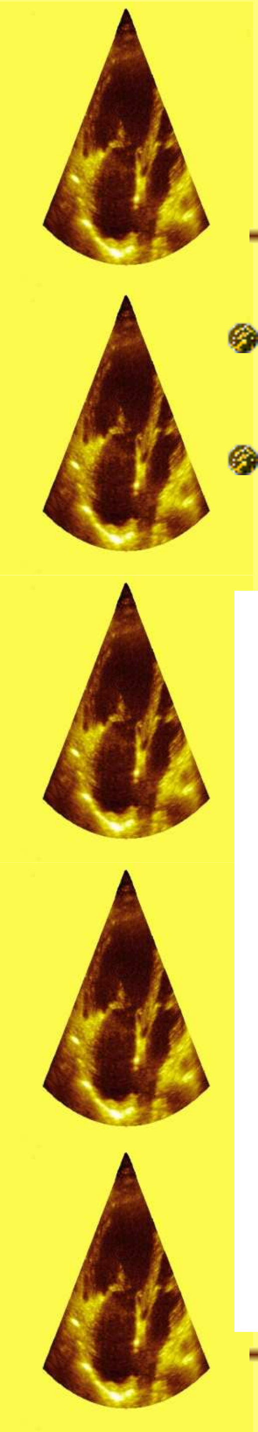
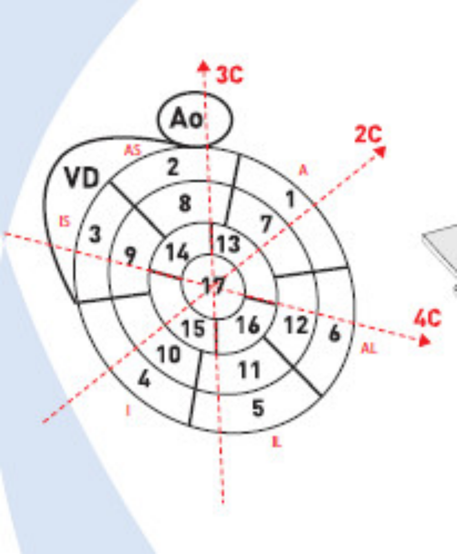




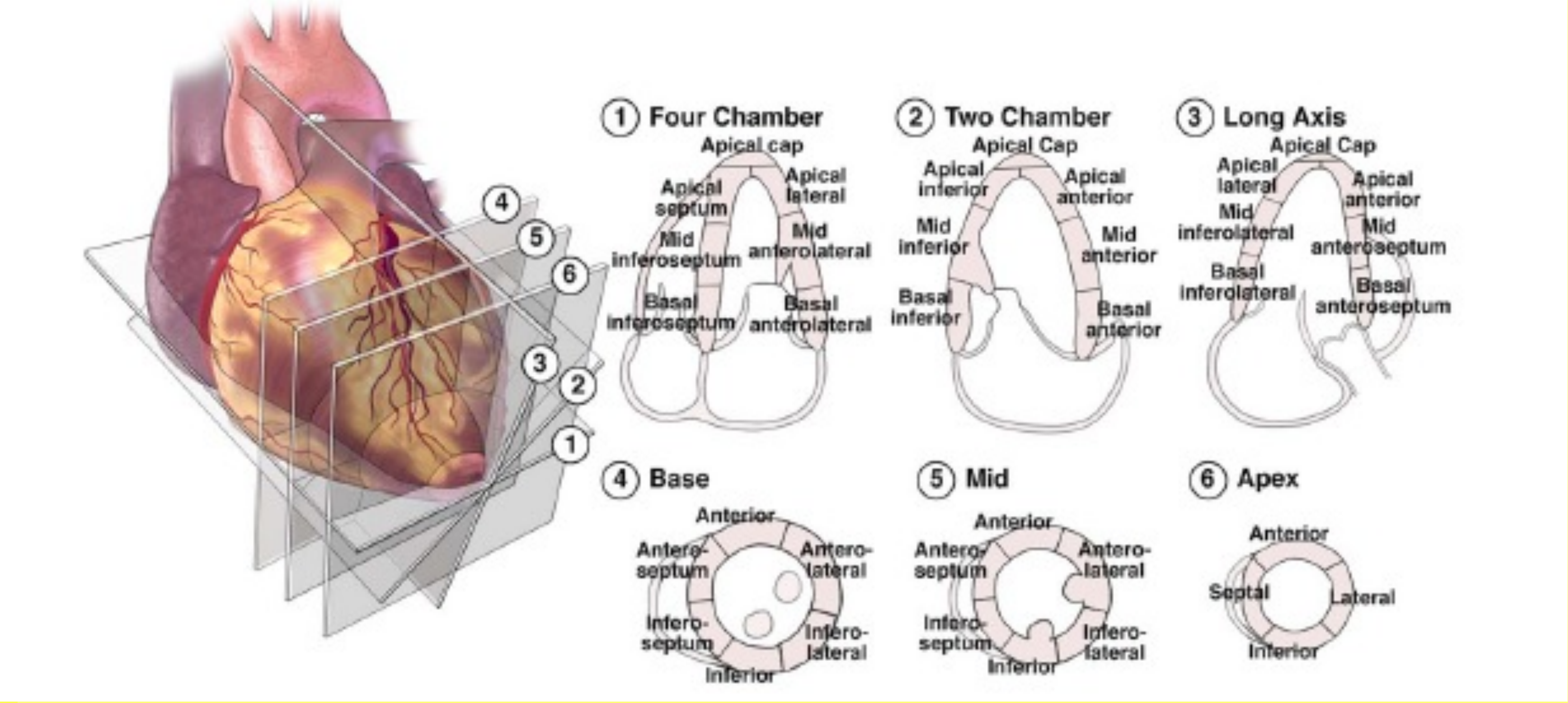




2D : morphologie et cinétique régionale



- Dilatation cavitaire, cinétique gl
- Analyse segmentaire



R. Lang 2006, recommandation for chamber quantification

Vascularisation coronaire

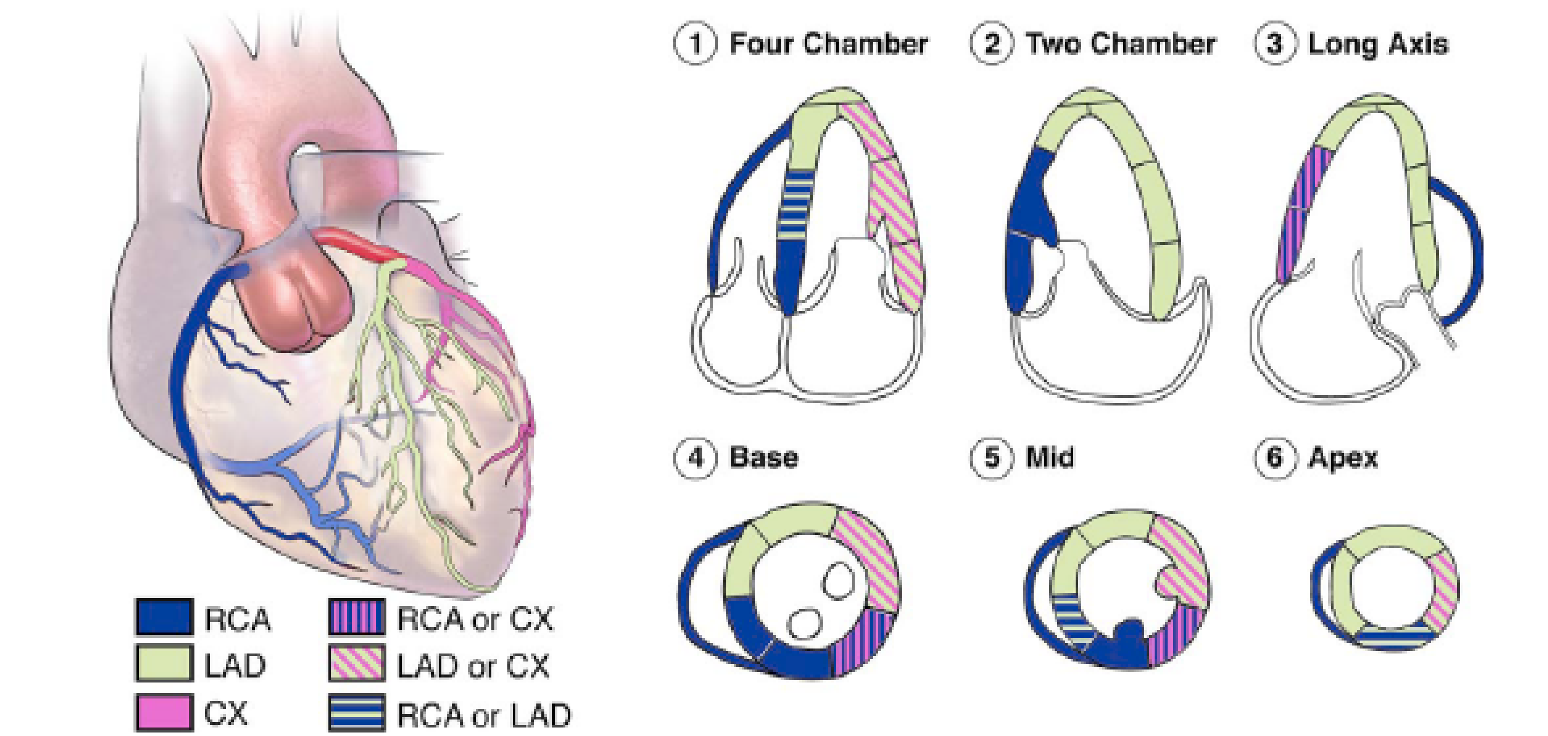
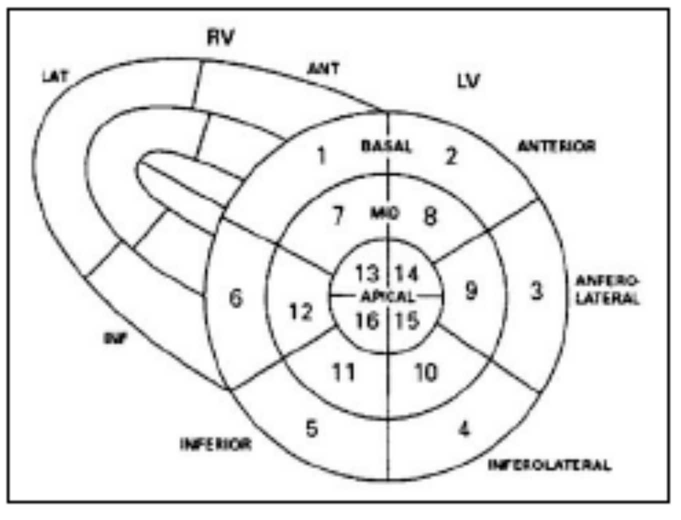
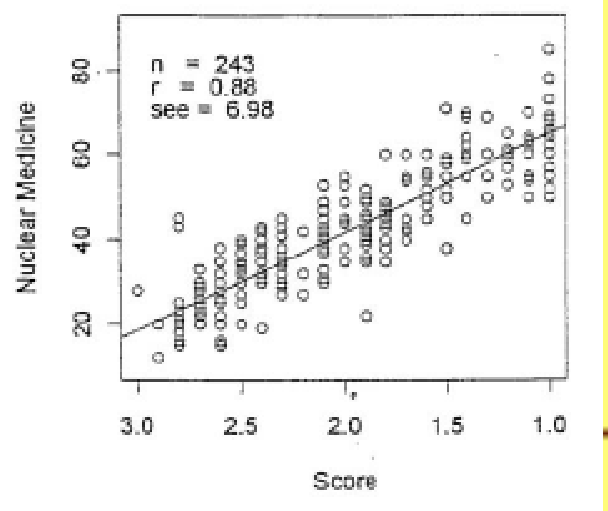


Figure 9 Artist's diagram showing the position of three long axis views and one short axis view of the left ventricle, showing the typical distributions of the right coronary artery (RCA), the left anterior descending (LAD), and the circumflex (Cx) coronary arteries. The arterial distribution varies between patients. Some segments have variable coronary perfusion.

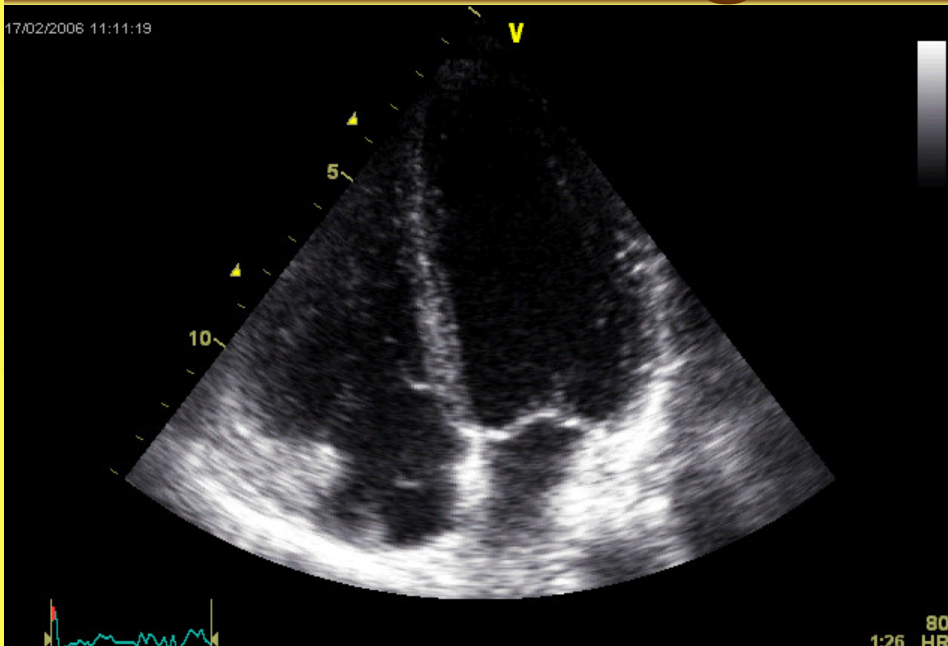
2D : Cinétique régionale

- Evaluation de la cinétique segmentaire :
  - Normokinétique 1 épais. >30%
  - Hypokinétique 2 épais.11-30%
  - Akinétique 3 épais. 0-11%
  - Dyskinétique 4 épais. Négatif
- Calcul du score de cinétique pariétale



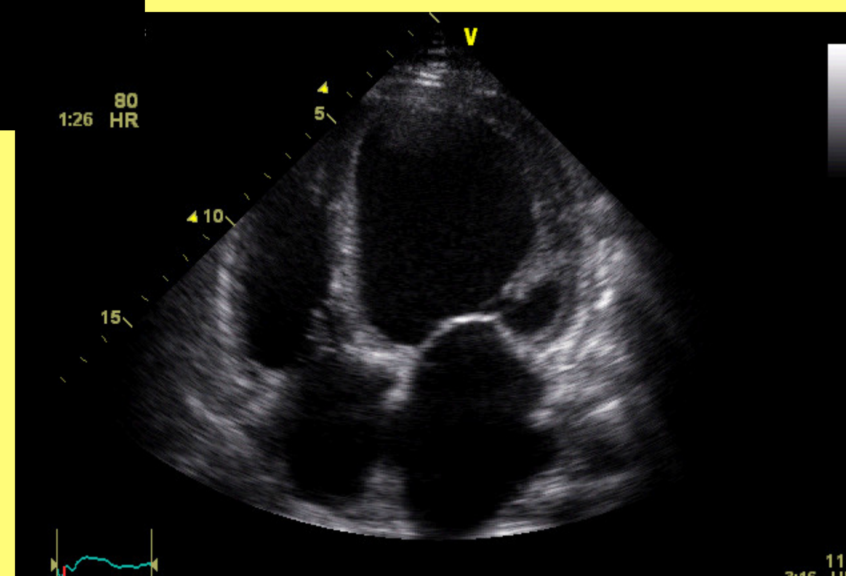


2D : Cinétique globale et régionale

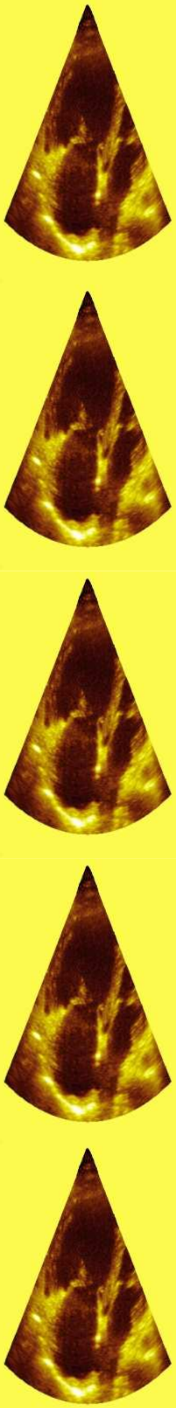


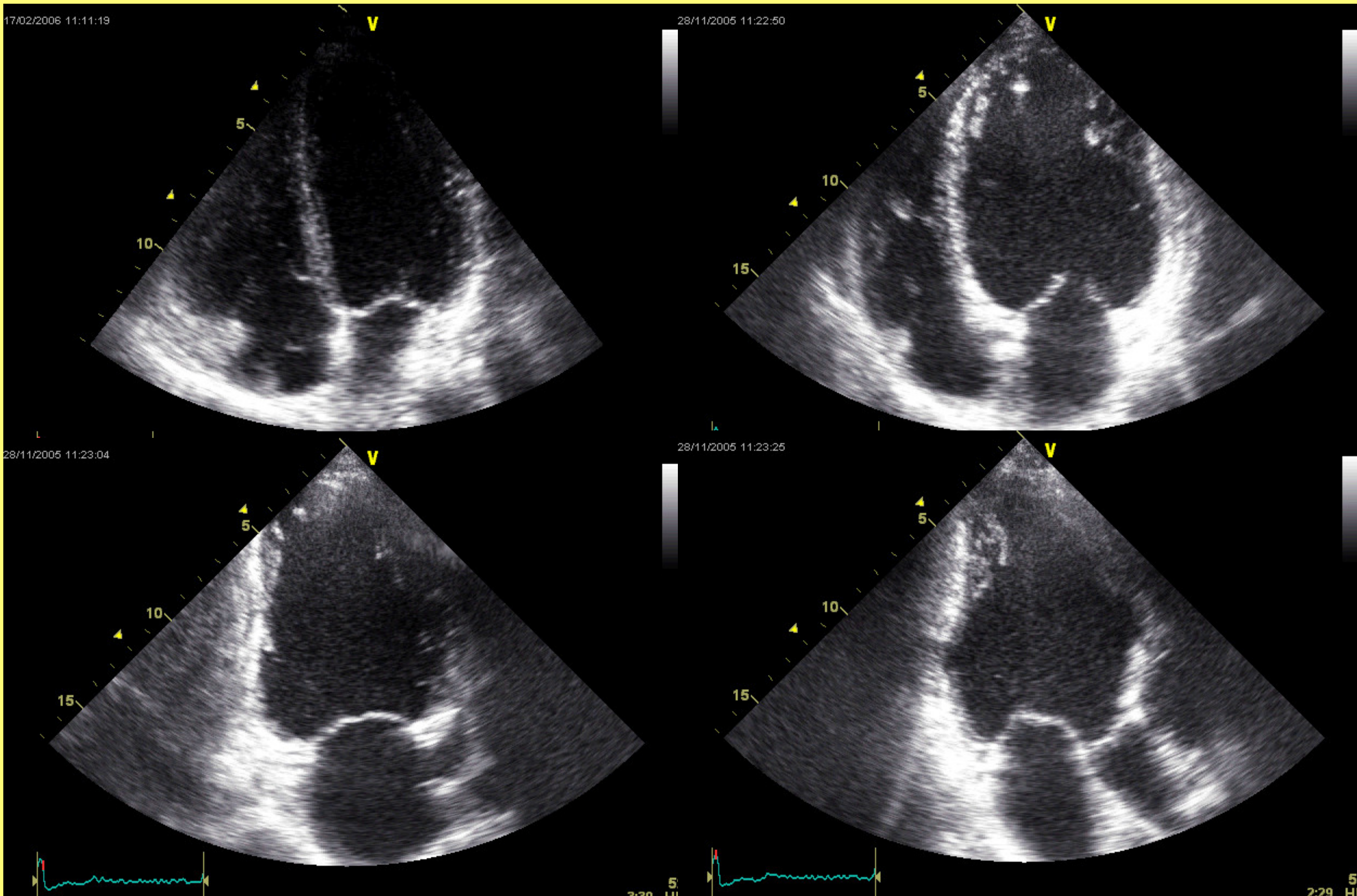
- Echo normale

- Cardiomyopathie dilatée hypokinétique



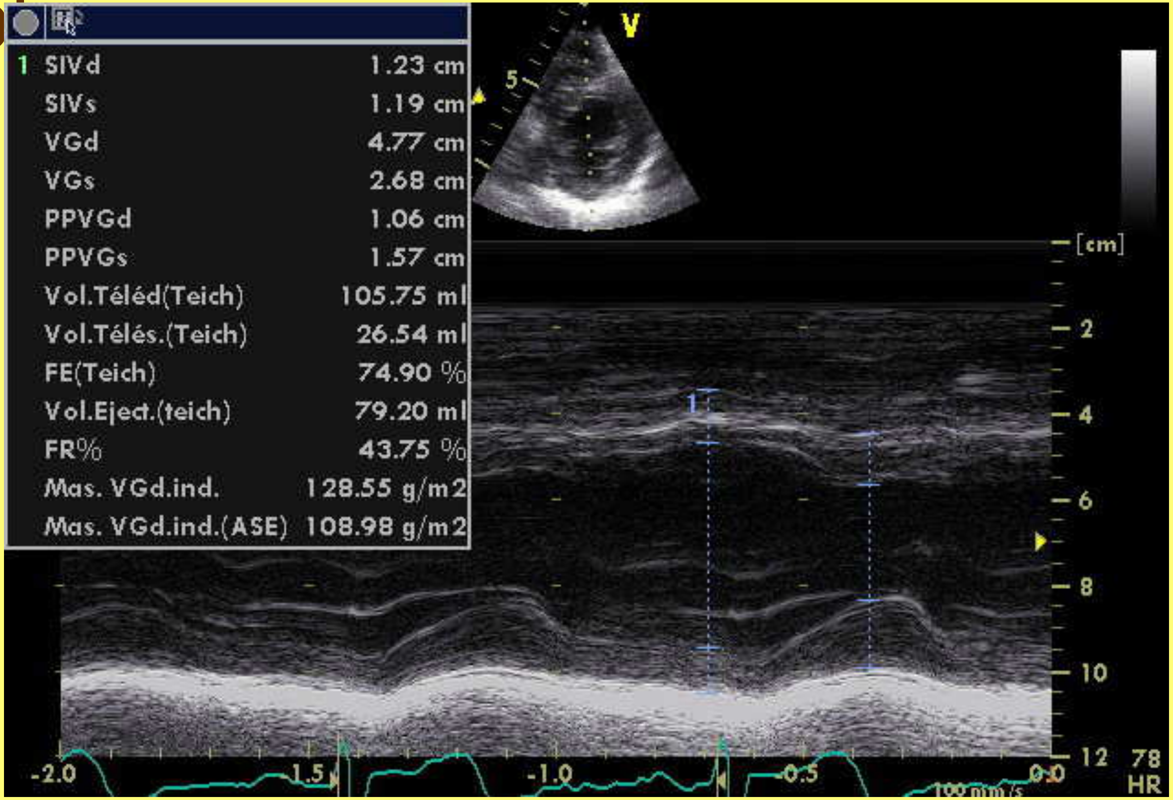
2D : cinétique globale et régionale





Mesures en mode TM

- Fraction de raccourcissement
- Fraction d'éjection selon Teichholz, à oubli



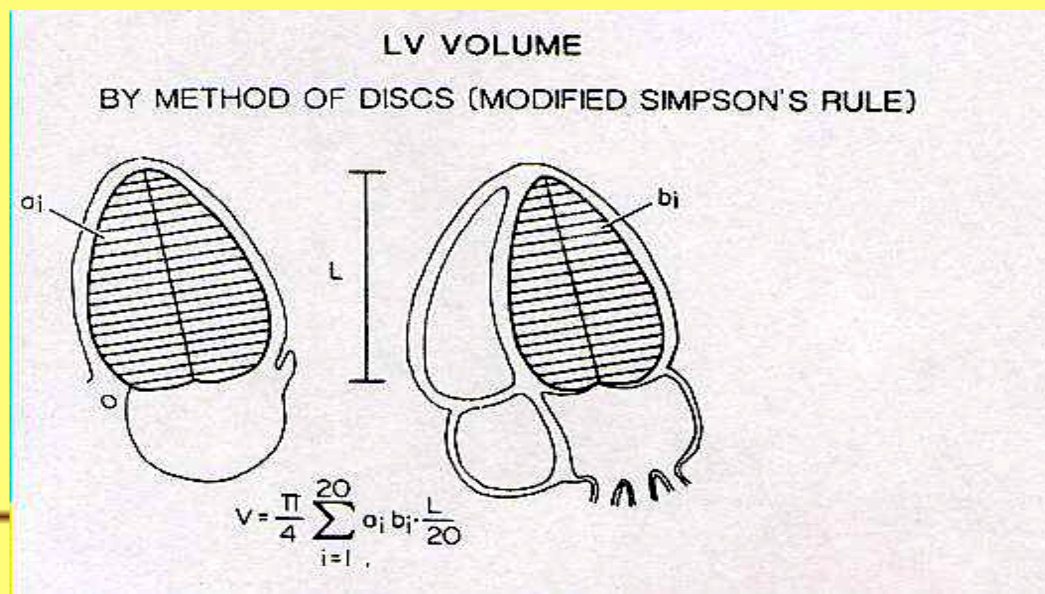
Mesures en 2D

- **Différentes méthodes**
  -
  -
    -

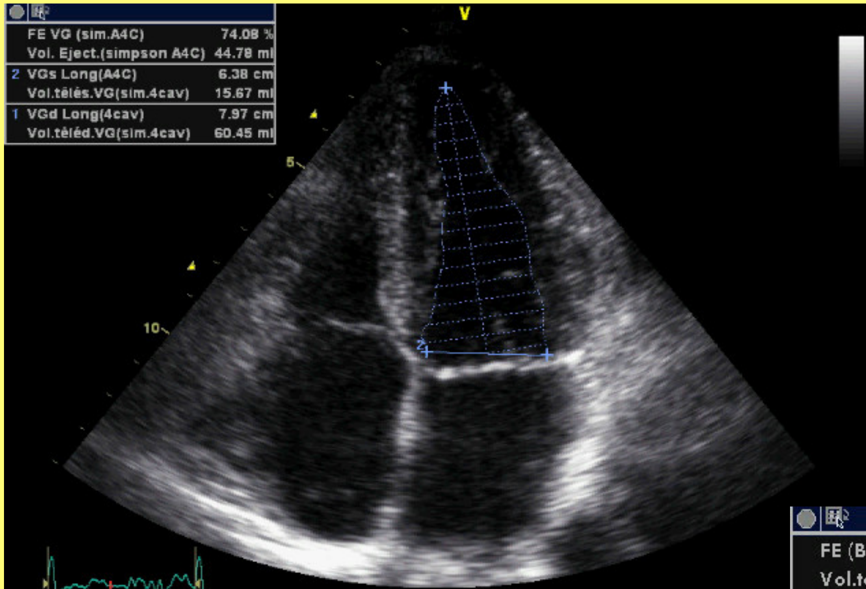
      endocardiques télédiastoliques et télésystoliques

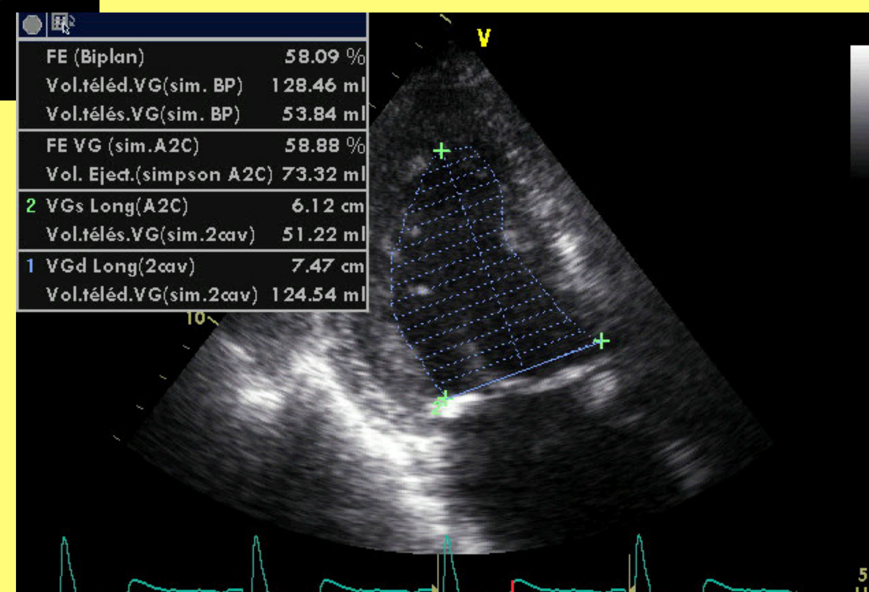
  - Estimation des volumes à partir des contours endocardiques télédiastoliques et télésystoliques
- Estimation visuelle

  (harmonique, double focalisation)

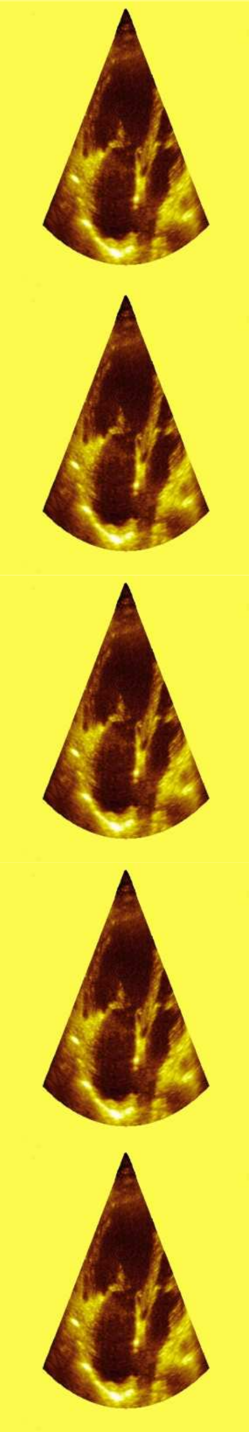


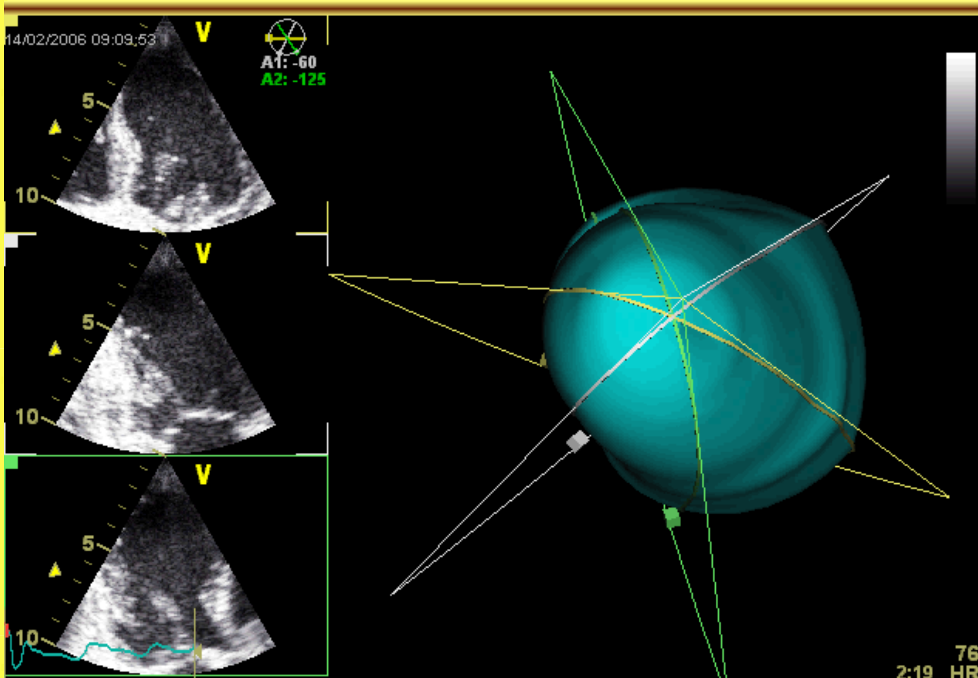
FE VG en écho 2D

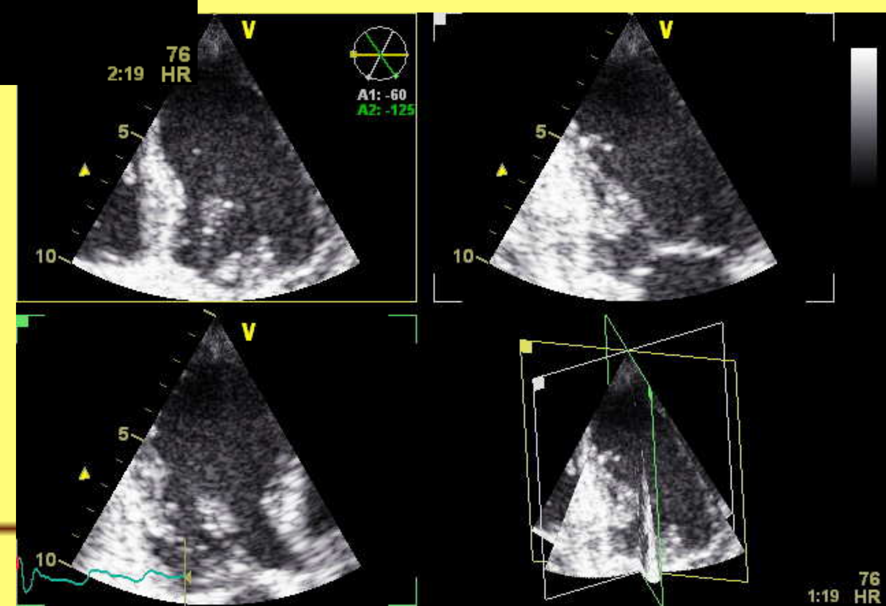




Mesures en 3D

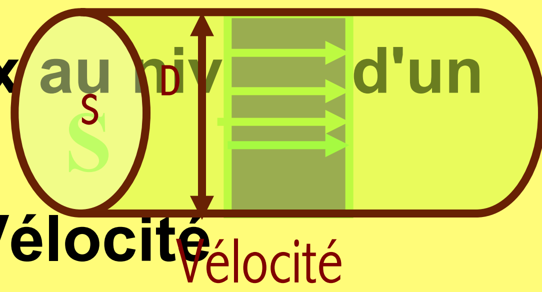






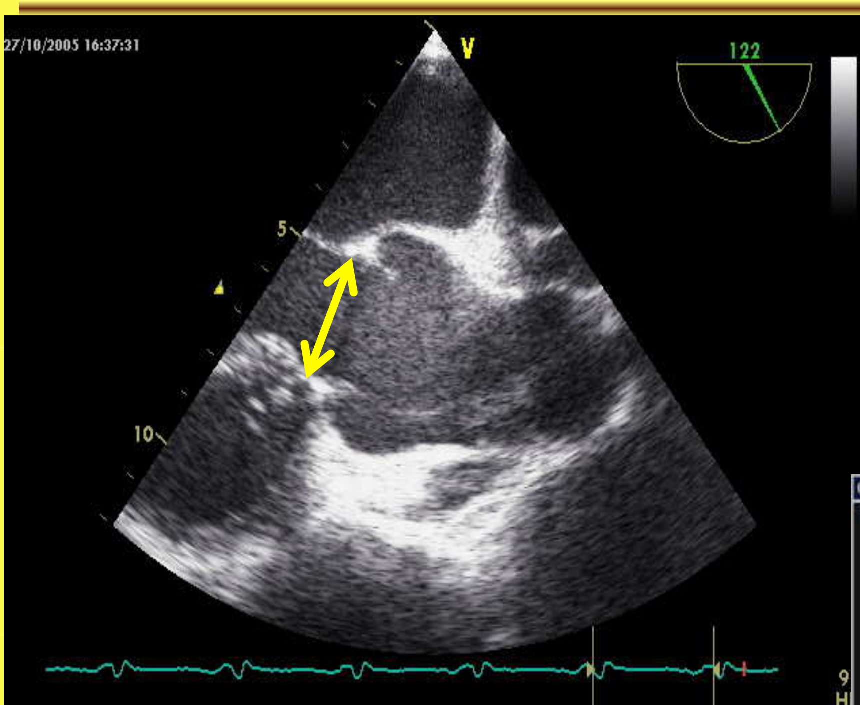
Le débit cardiaque

- **Qc = Volume éjecté X Fréquence cardiaque**
- **Plusieurs modes de mesure du débit cardiaque**
  - **Technique Doppler**
    - **estimation à partir de V du flux au niv d'un orifice valvulaire**
    - **Débit = Surface de l'orifice X Vélocité**
    - **Q(cm^3/mn)=S(cm^2) x ITV (cm) x FC(mn^{-1})**
    - **S = π $D^2/4$**

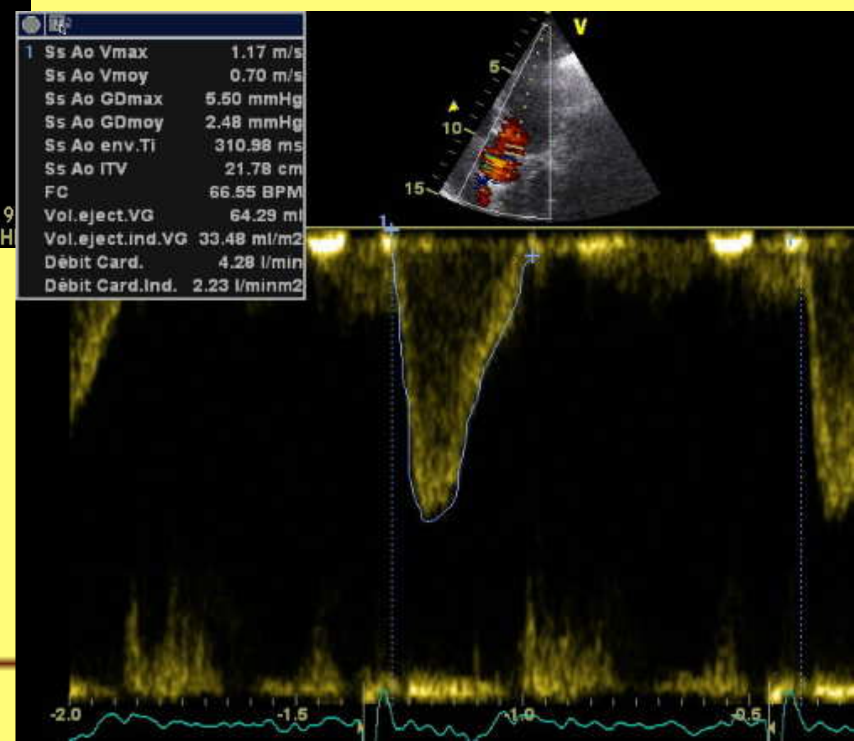


  - **Techniques des volumes :**
    - **différence Volume ventriculaire**

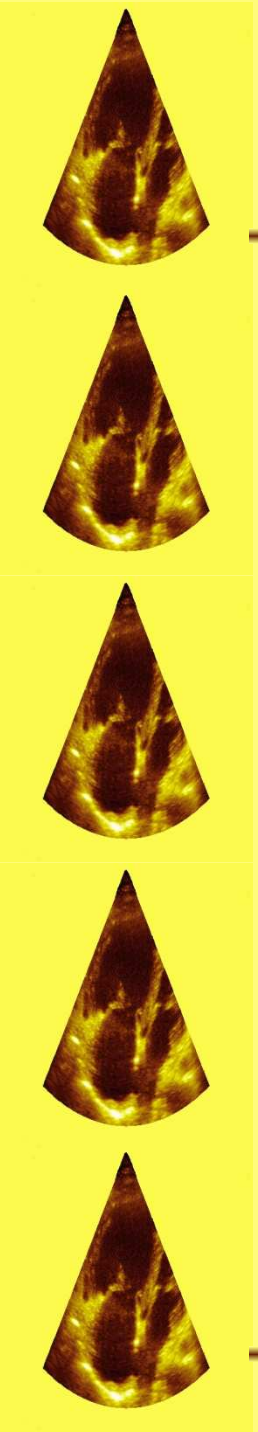
Technique Doppler à l'anneau aortique



- Diam sous Ao = 19 mm
- VTI sous Ao = 21.7cm

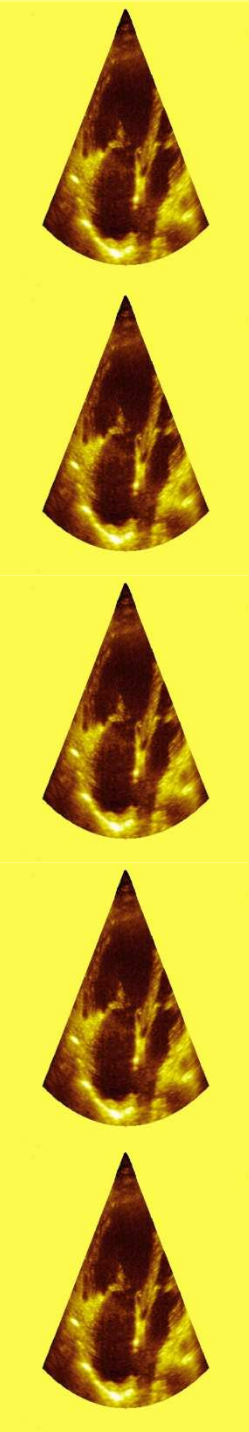


- FC = 66 bpm
- Qc = 4.28 l/mn



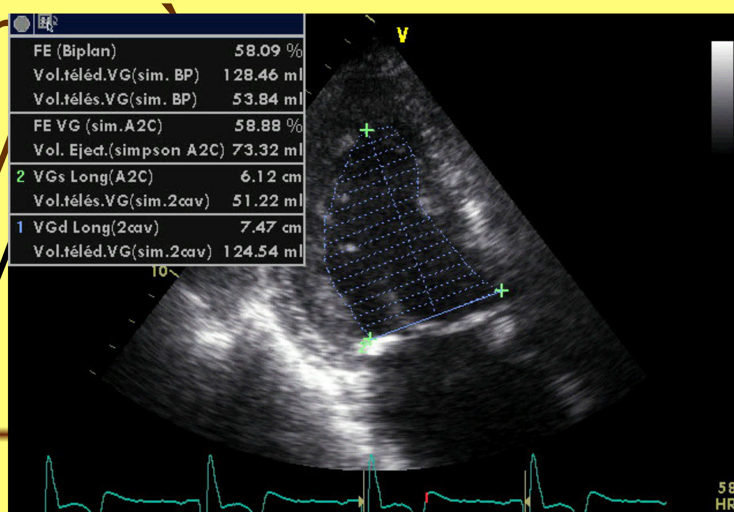
Technique Doppler à l'anneau aortique

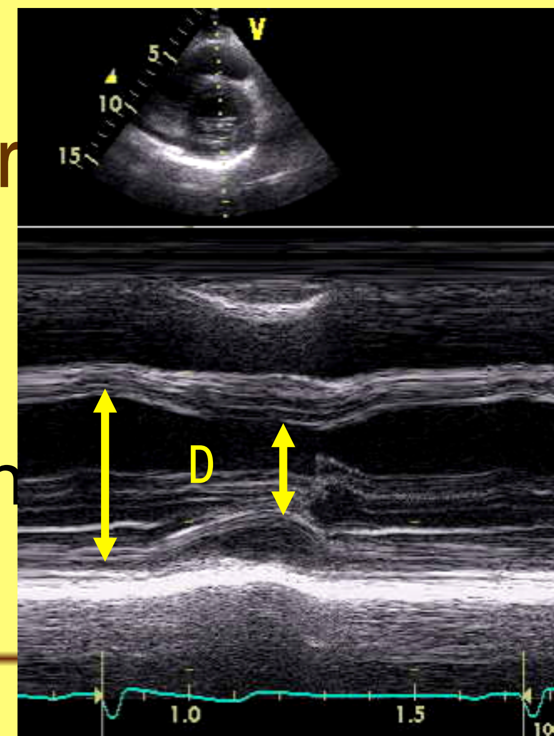
- Technique fiable et reproductible si
  - Rythme régulier (sinusal)
  - Absence d'obstruction sous aortique
  - Mesure fiable de D (car erreur portée au carré…)
  - Enregistrement du flux au centre de l'anneau aortique (r = 0.93, SEE = 0.589 l/mn vs thermodilution)
  - Opérateur entraîné et échogénicité correcte

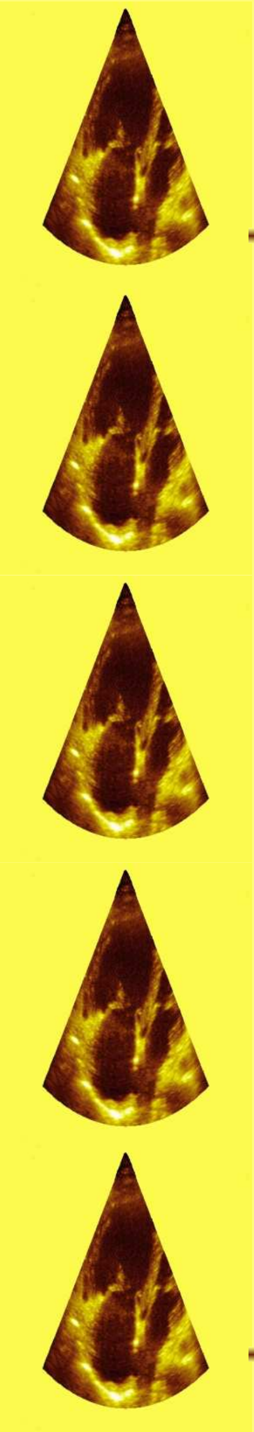


Technique des volumes

- Estimation des volumes à partir TM ou 2D
  - Fiable si rythme régulier
  - Fiable si pas de régurgitation valvulaire significative
- Mesure TM fiable si contr… hor… …
  - V…
  - V… …eich…





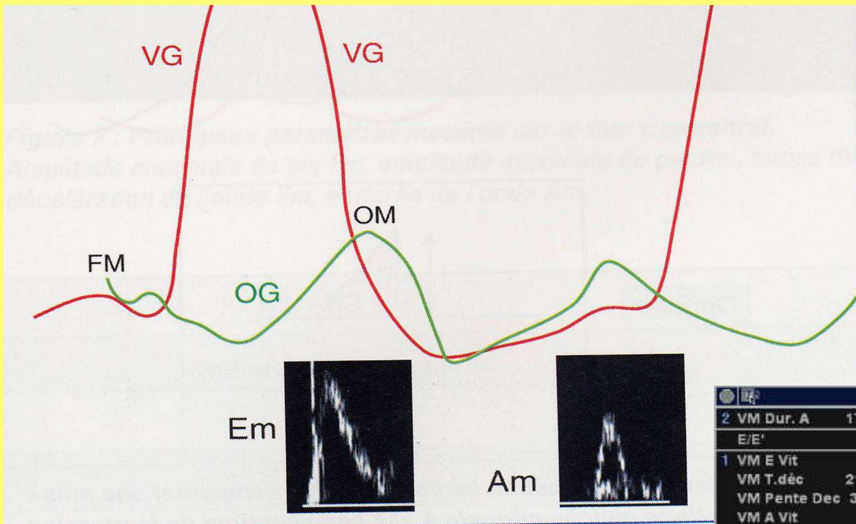


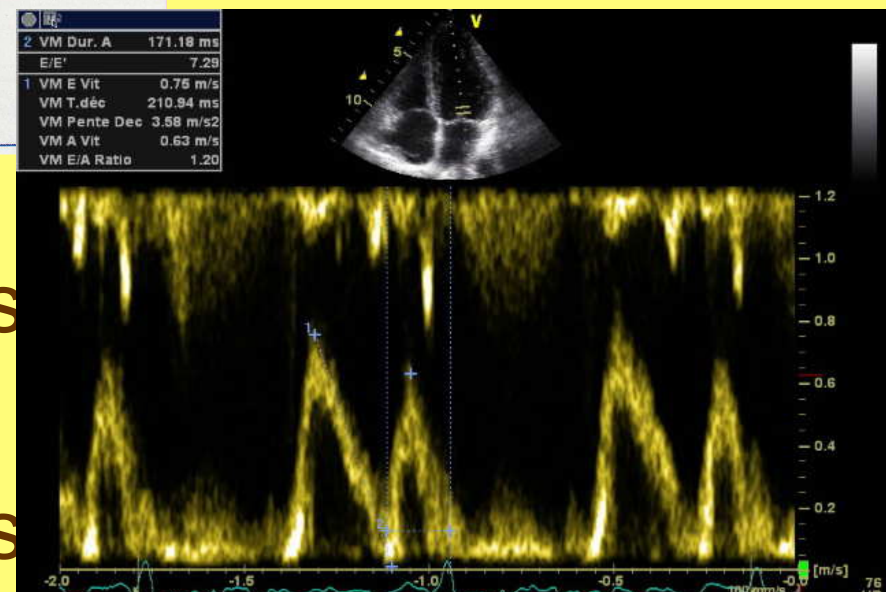
Fonction diastolique

- Plus complexe
- Dépend de différents facteurs
  - Myocardiques :
    - Actifs : relaxation = succion ventriculaire
    - Passifs : compliance, rigidité = propriétés viscoélastiques
  - Autres
    - Contraction atriale
    - Interaction VD-VG
    - Contrainte péricardique
- Première approche : le flux mitral

Le flux mitral

- Gradient OG-VG = déterminisme du

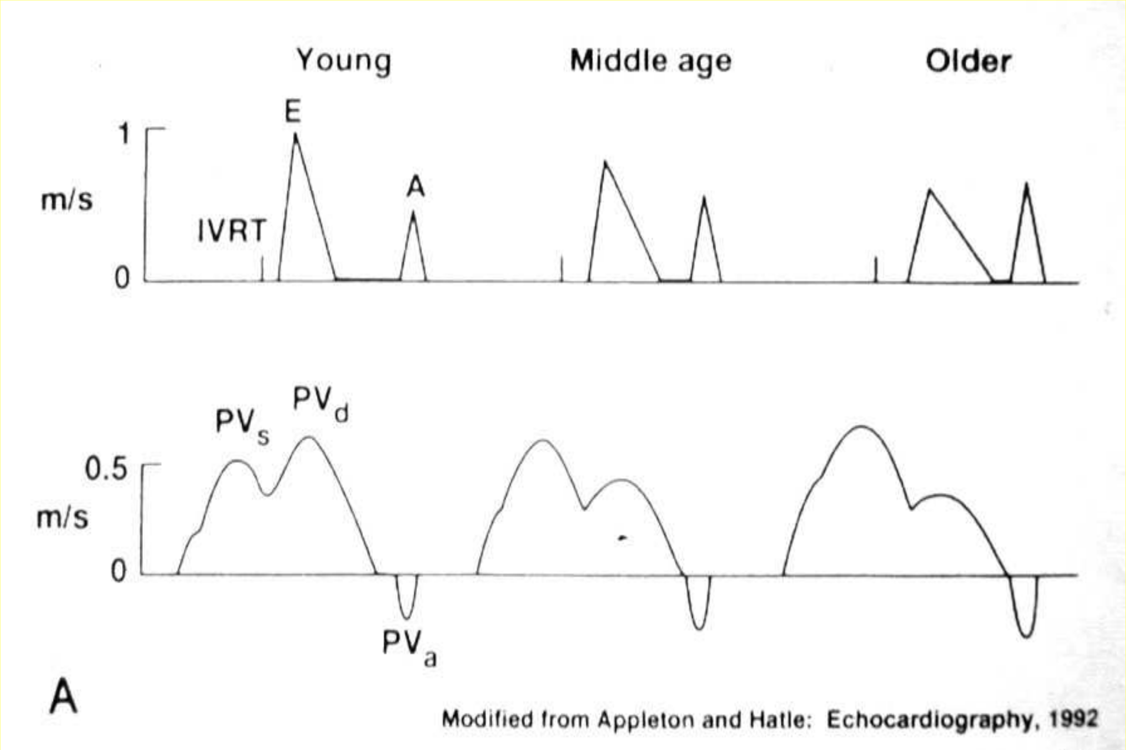


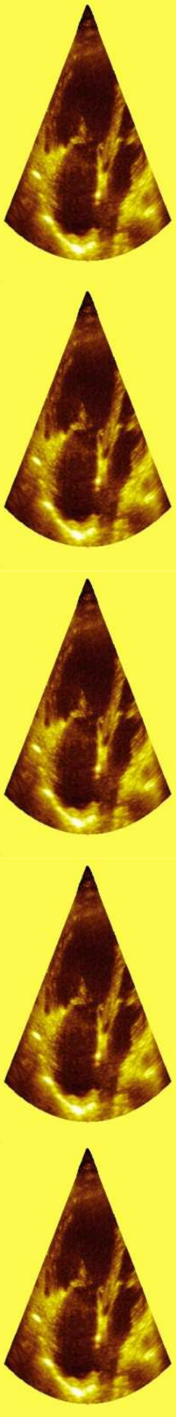


- Onde E = rempliss
actif
- Onde A = rempliss
passif

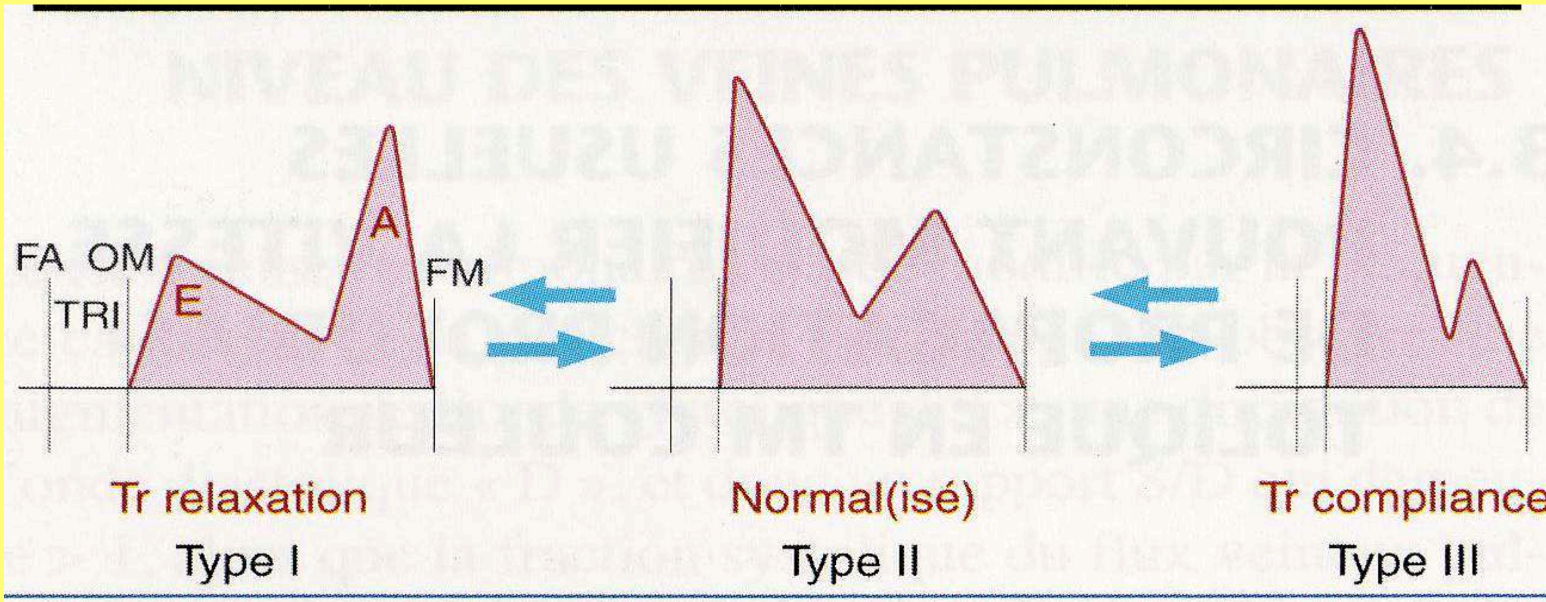
Le flux mitral

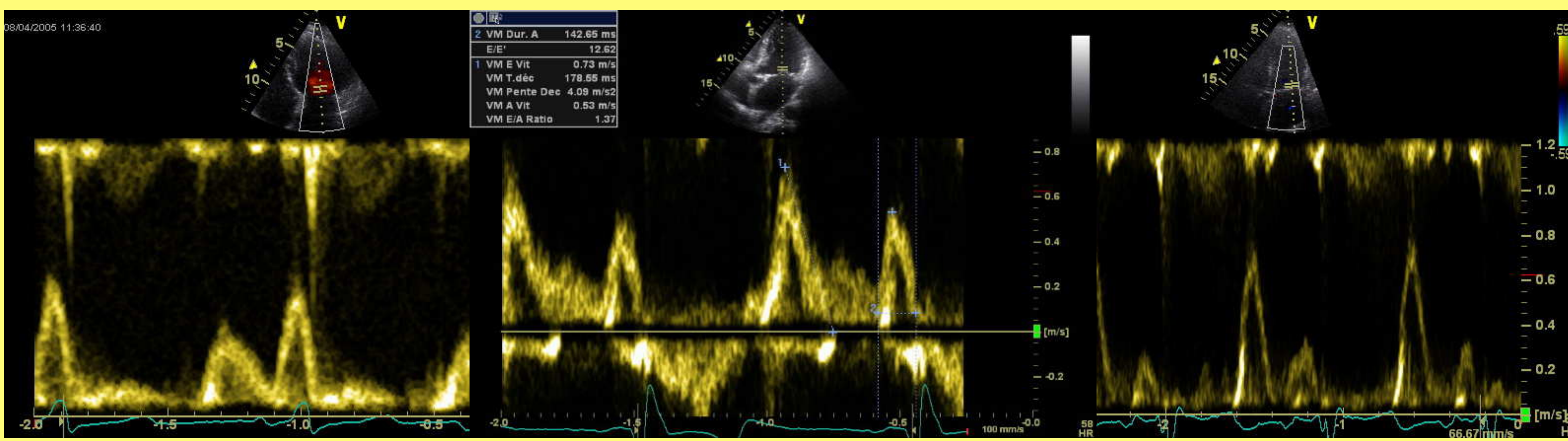
- Flux mitral évolue avec l'âge : diminution progressive du rapport E/A





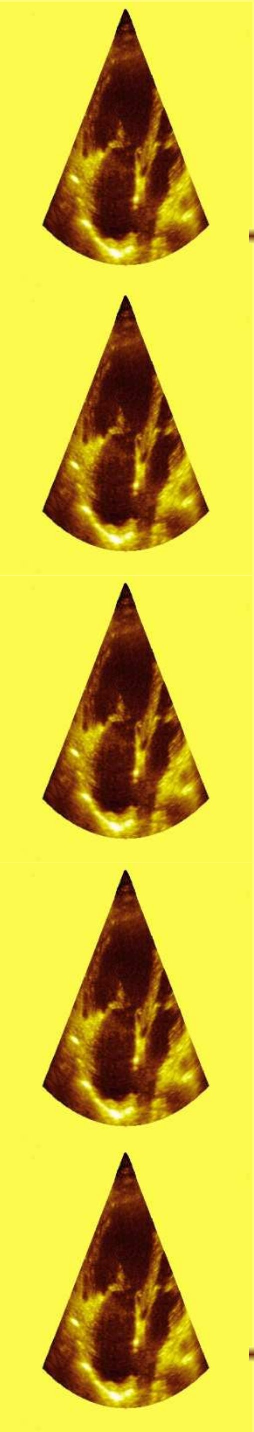
Stades de dysfonction diastolique

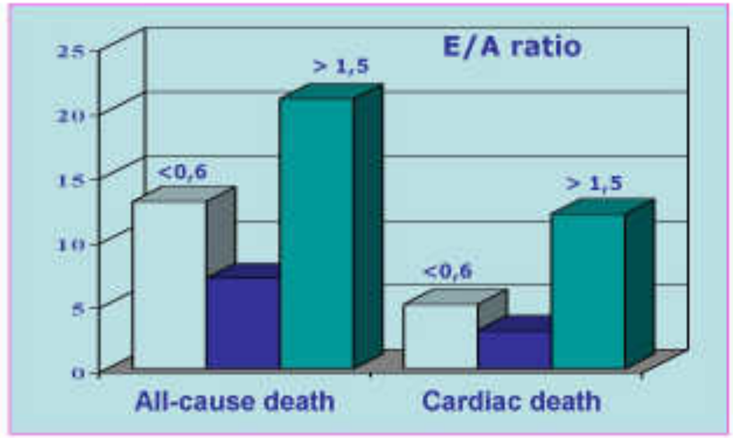


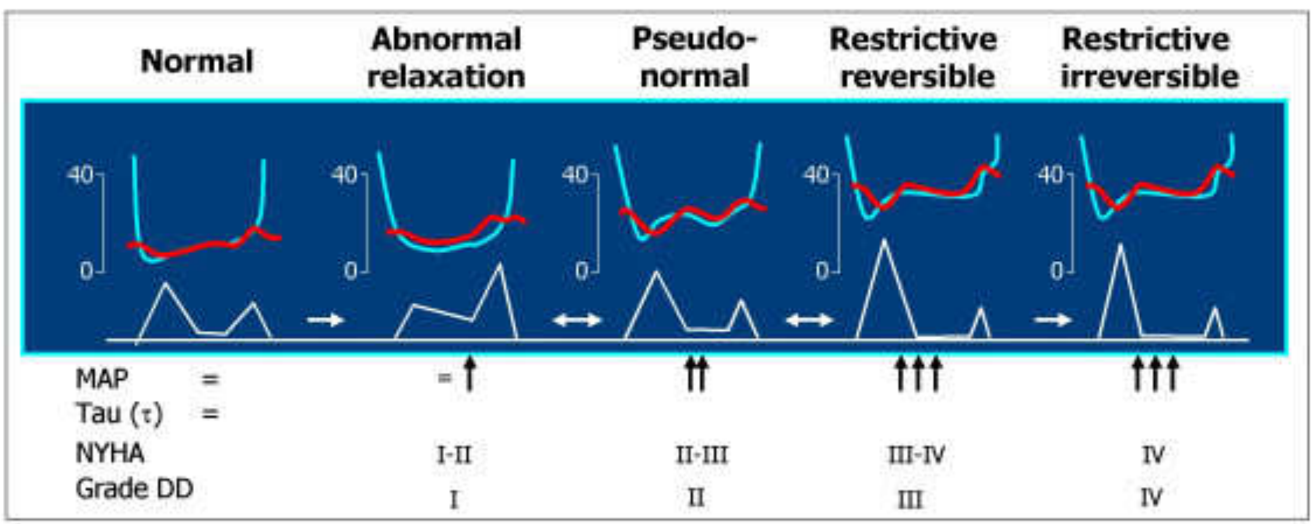


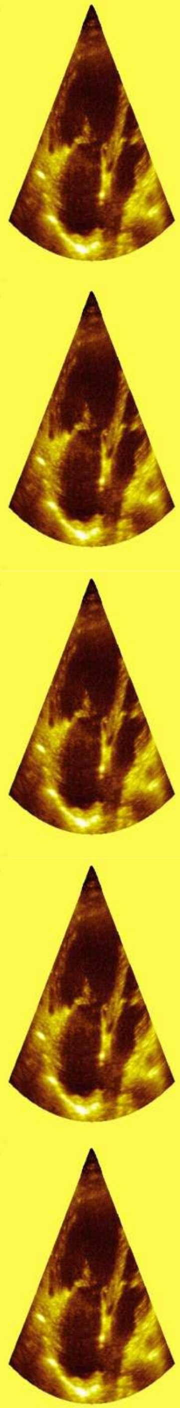
Tr relaxation pseudo normal type

Stades de dysfonction diastolique

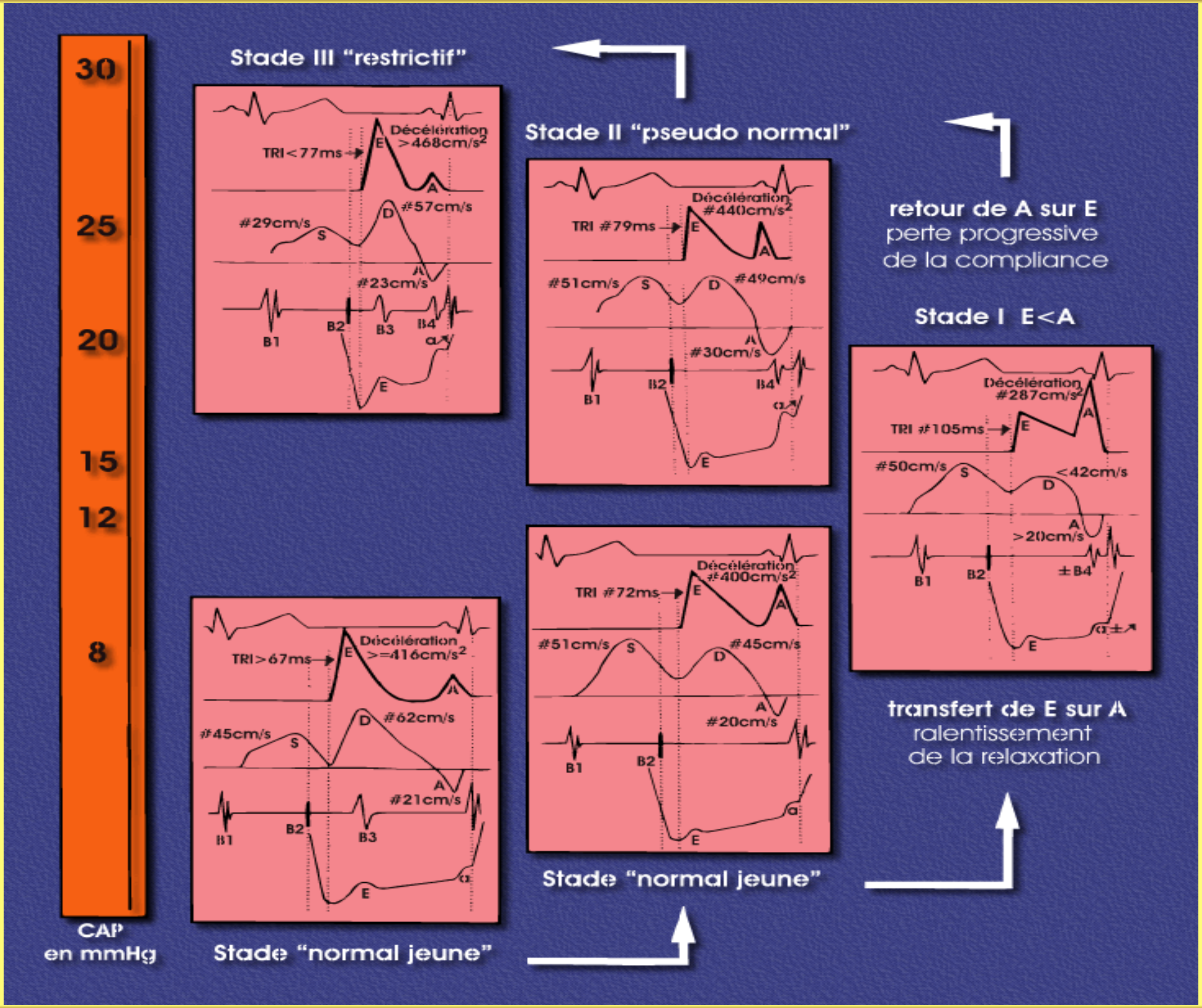




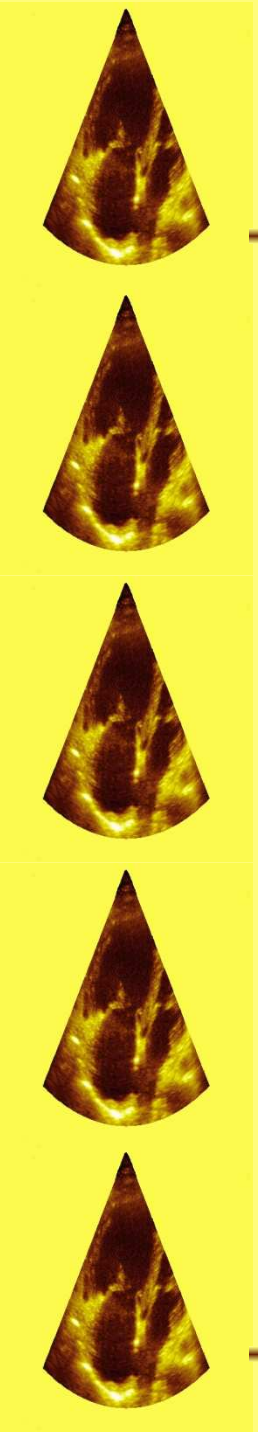




Différents stades de dysfonction diastolique



Intérêt thérapeutique et pronostique

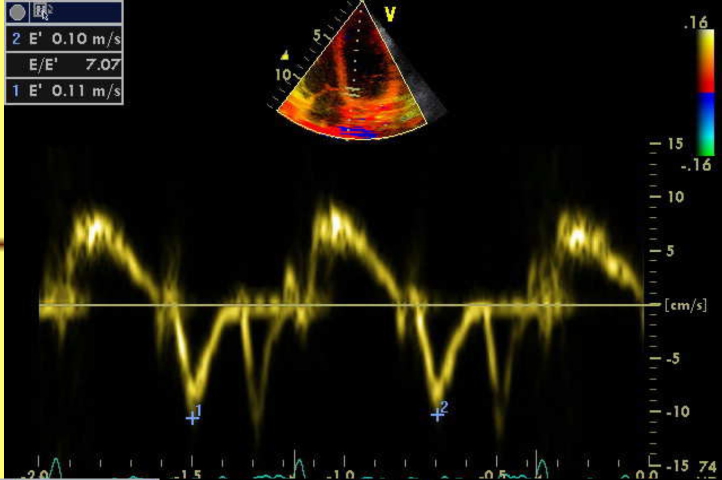


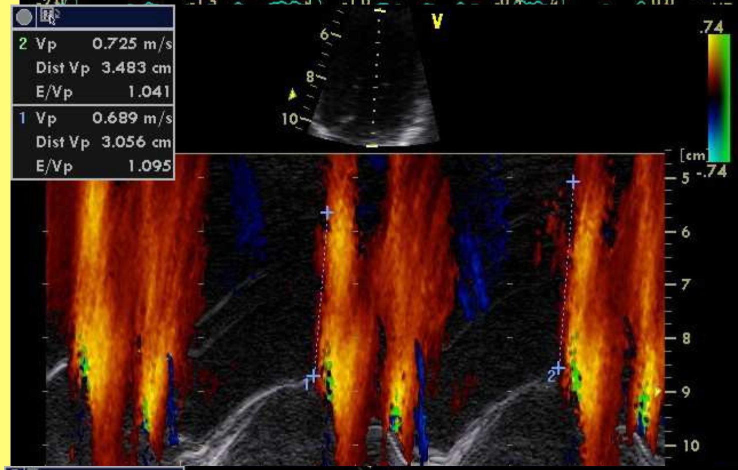
Analyse de la diastole

- Le DTI au niveau de l'anneau mitral

- La vitesse de propagation du flux de remplissage VG

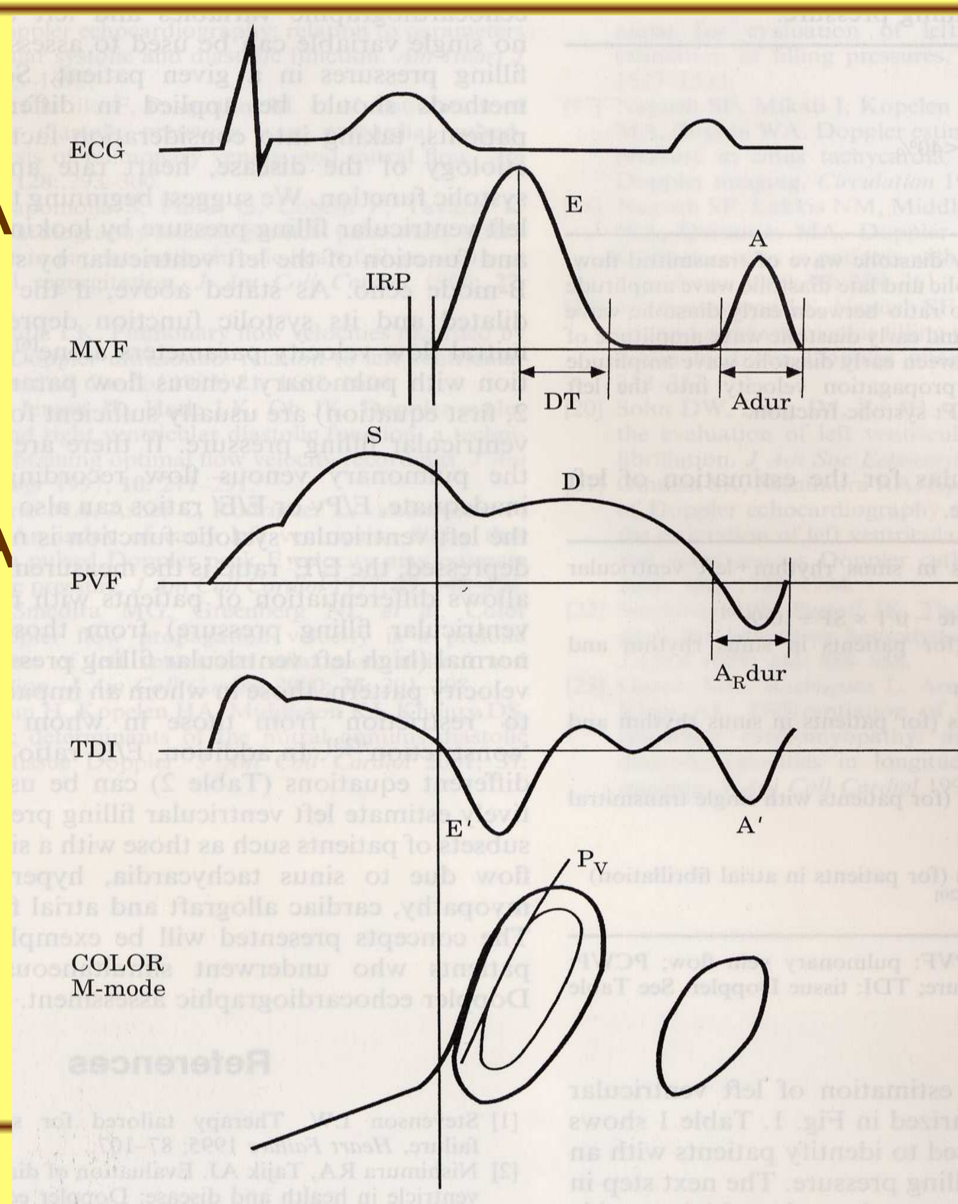
- Le flux veineux pulmonaire



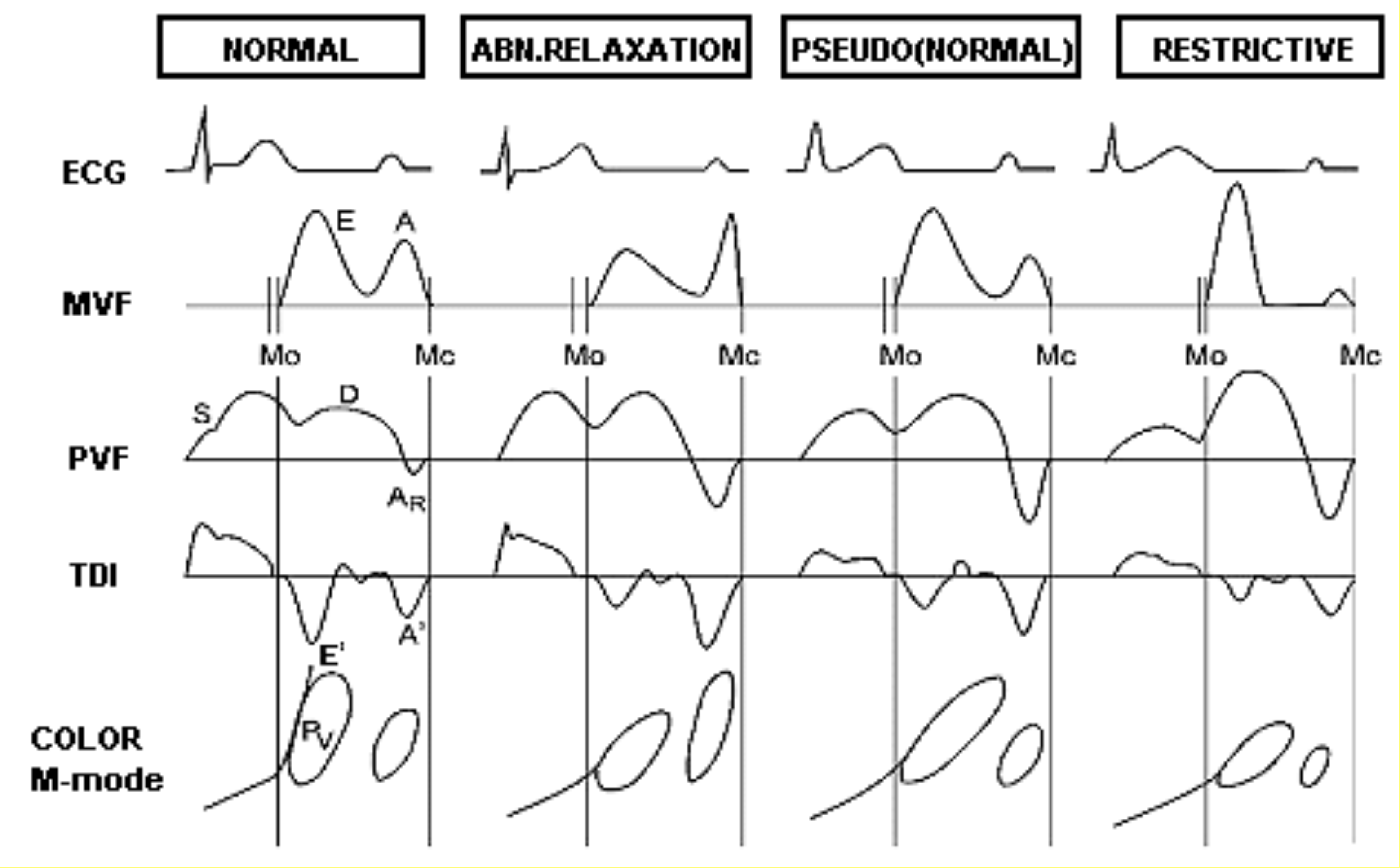


Analyse de la diastole

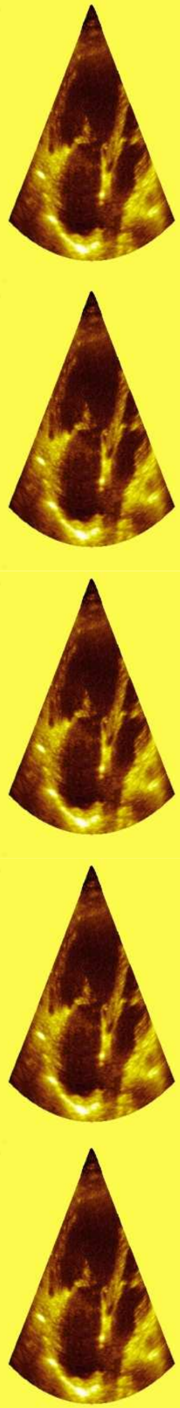
- Flux mitral
  - E/A, durée onde A
- Flux veineux pulmonaire
  - S/D, durée onde A
- DTI anneau mitral
  - E', E'/A'
- TM couleur
  - vitesse de propagation

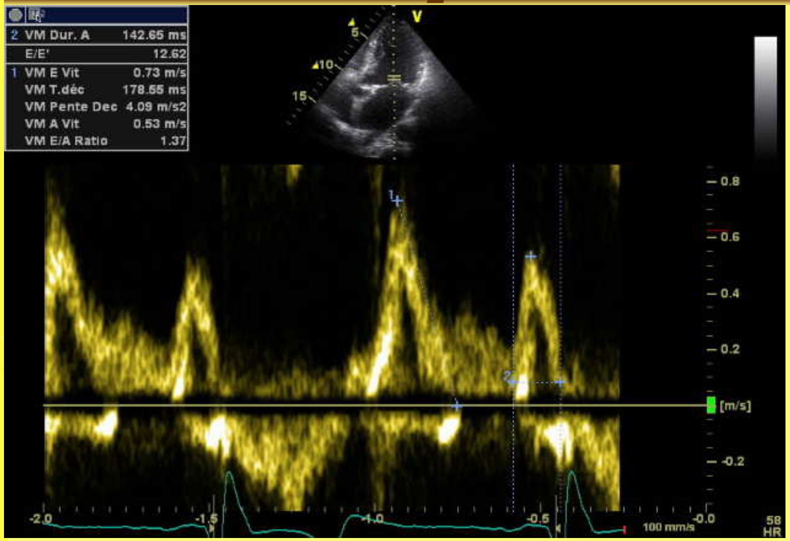


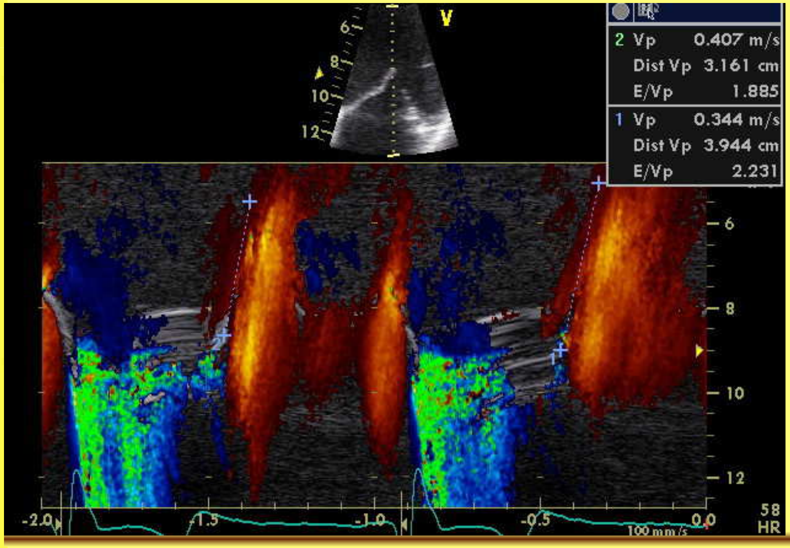
Différents stades de dysfonction diastolique

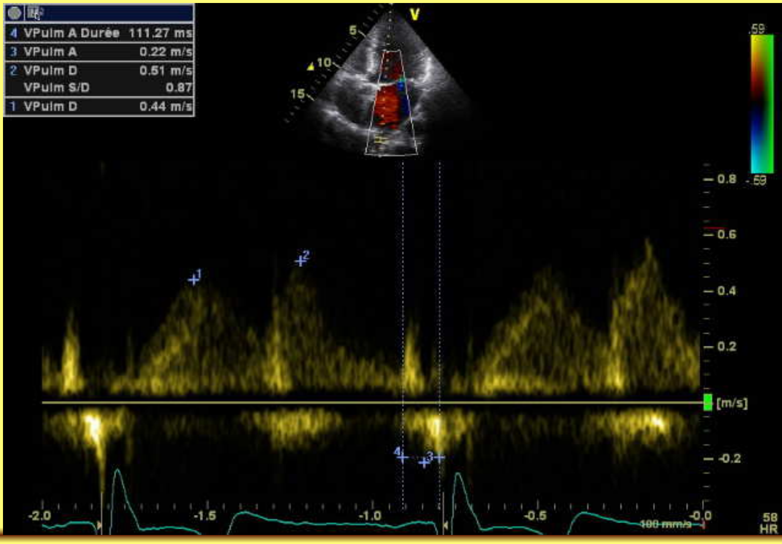


Exemple clinique : flux pseudo normal

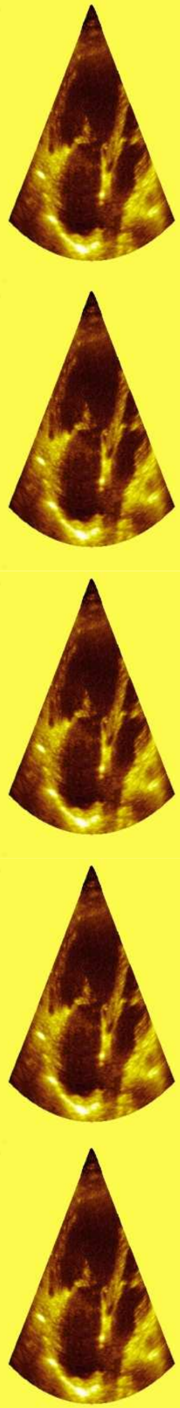


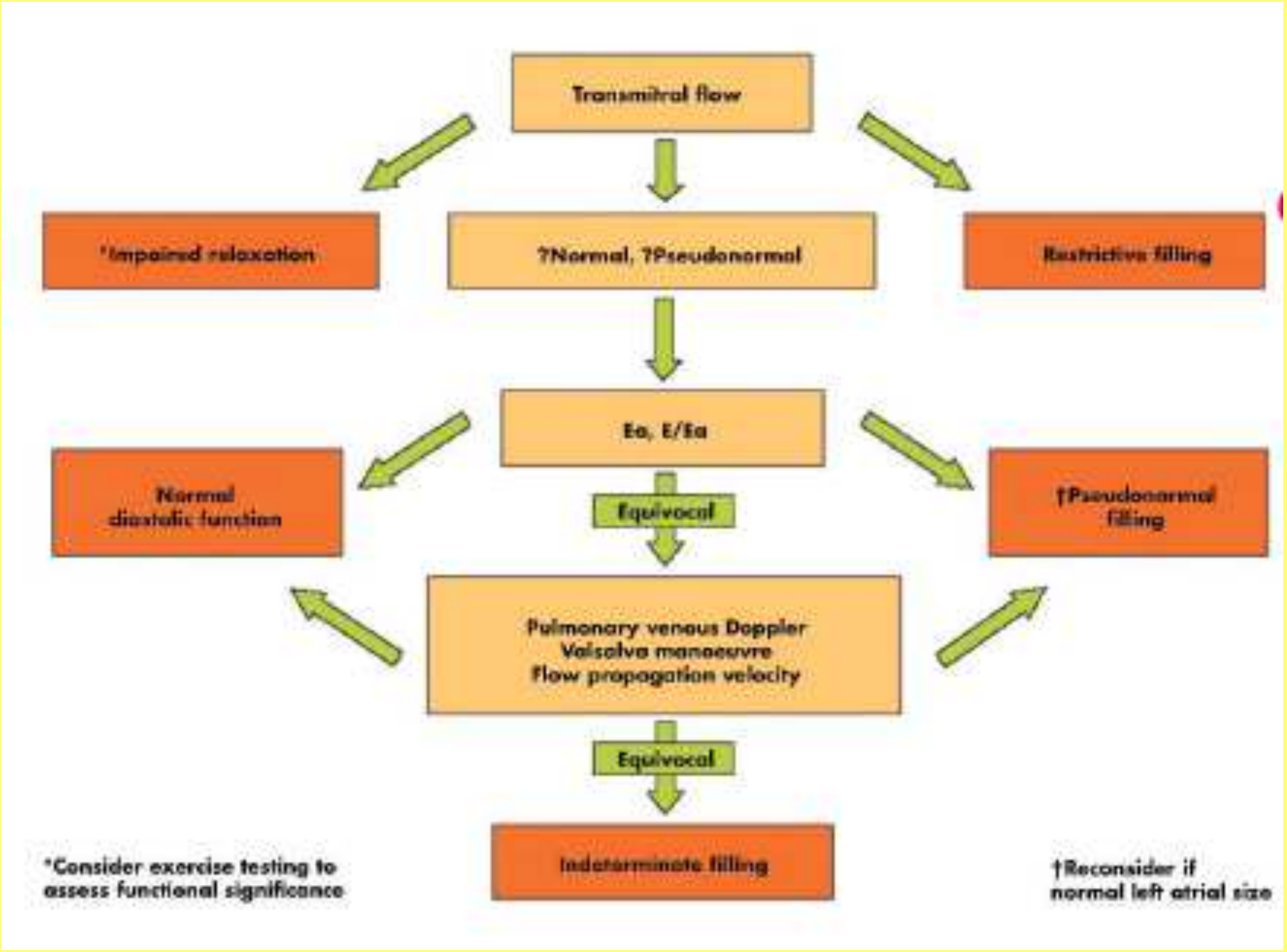


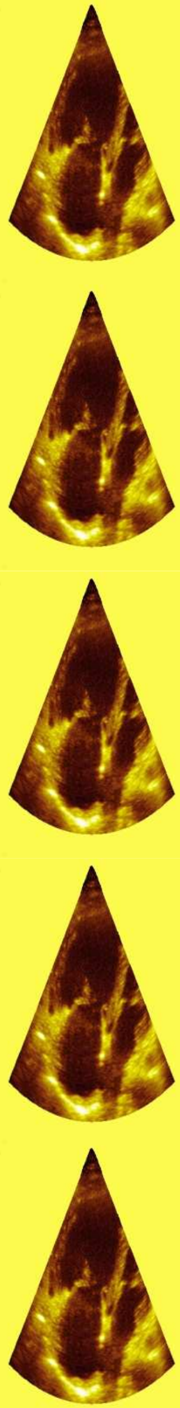




Algorithme d'interprétation





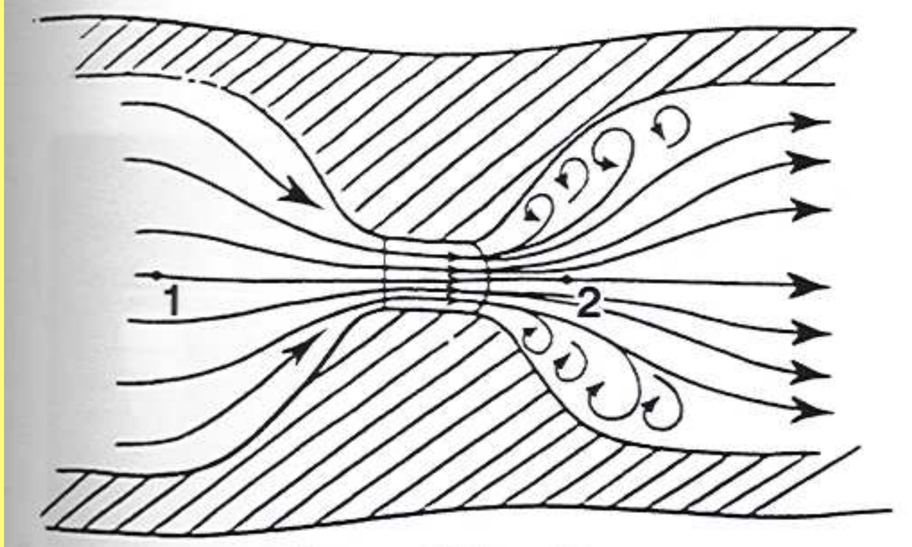


Conclusion

- L'échocardiographie est un examen très utile quand demandé à bon escient (en association avec un interrogatoire, un examen clinique et un ECG…)
- La réalisation d'une échocardiographie doit être rigoureuse, systématique et standardisée
- Elle permet d'obtenir une visualisation des différentes structures cardiaques et de leurs fonctions, avec un impact à la fois thérapeutique et pronostique

Calcul du gradient

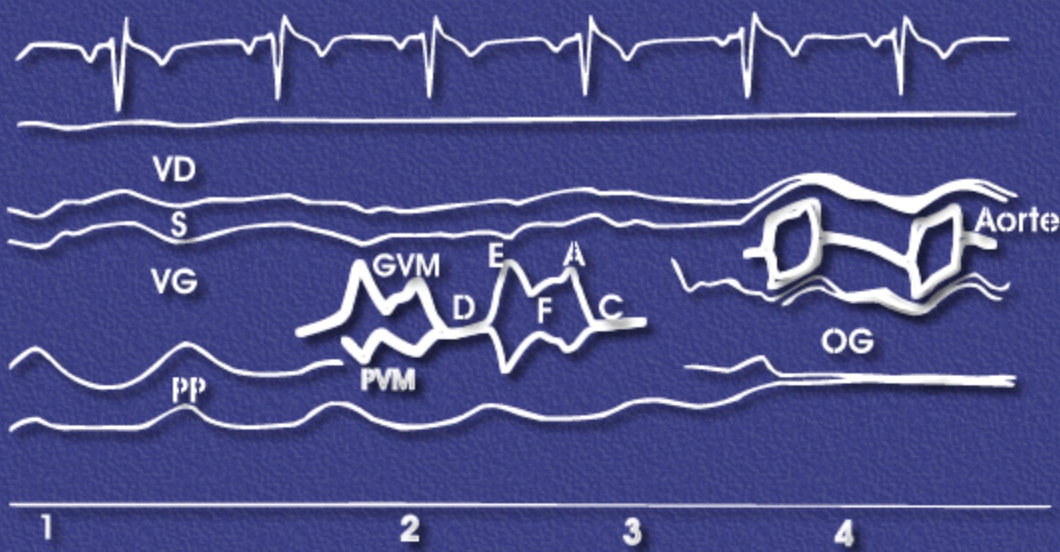
- Diamètre LVOT
- Calcul de la surface LVOT
- Tvi ou p max transvalulaire
- Doppler pulsé pour v lvot
- Calcul…



Bernoulli Equation

$$P_1 - P_2 = \underbrace{\tfrac{1}{2}\rho(V_2^2 - V_1^2)}_{\text{Convective acceleration}} + \underbrace{\rho\int_1^2 \frac{d\vec{v}}{dt}\,\vec{ds}}_{\text{Flow acceleration}} + \underbrace{R(\vec{V})}_{\text{Viscous friction}}$$

P_1 = pressure at location 1
P_2 = pressure at location 2
ρ = mass density of the blood 1.06×10^3 kg/m^3
V_1 = velocity at location 1
V_2 = velocity at location 2

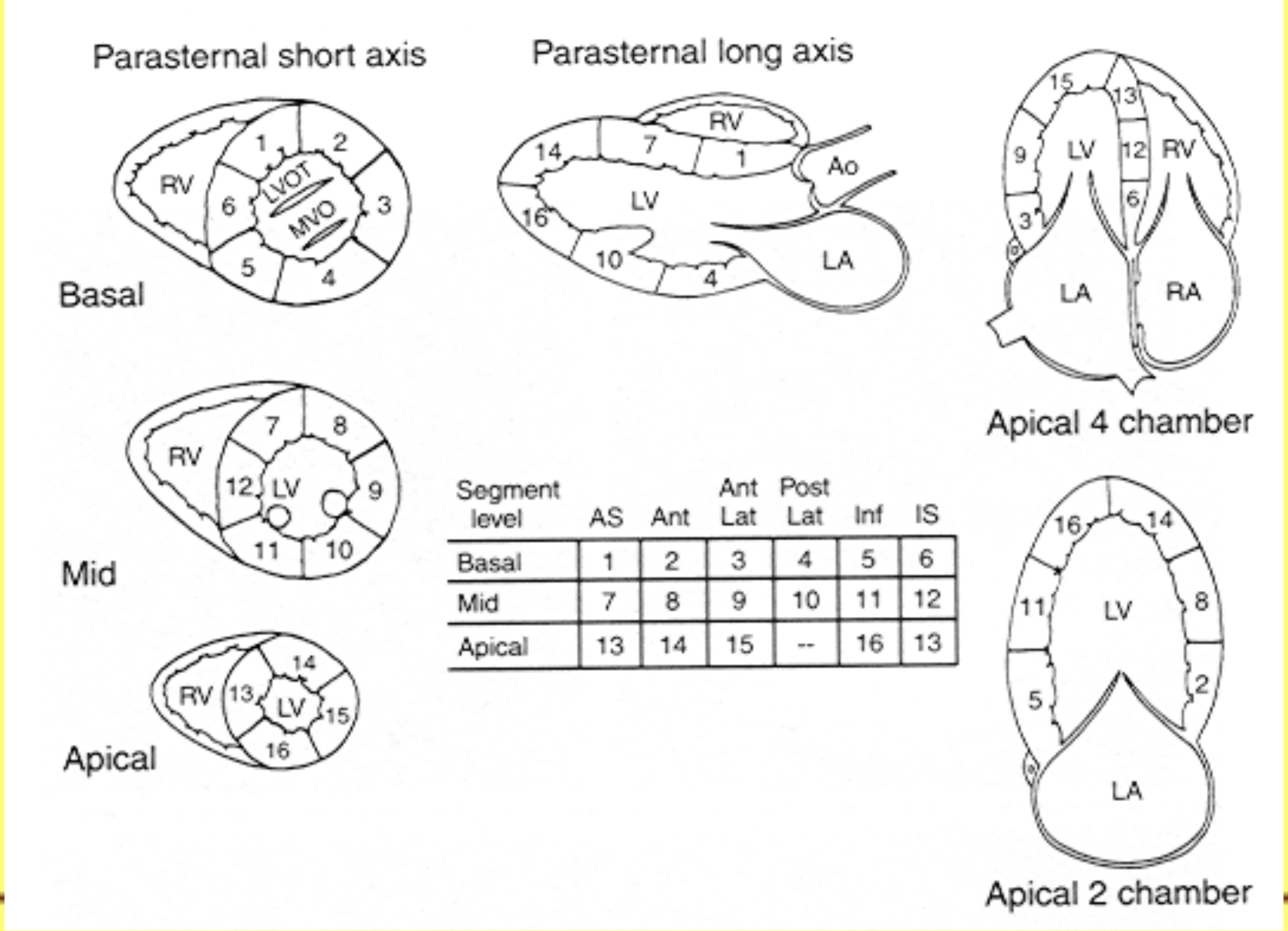


ECHOCARDIOGRAMME TM

En 1 : mesure du VG
En 2 : mesures de la mitrale (amplitude DE, pente EF)
En 3 : transition mitro-aortique
En 4 : mesure de l'aorte, ouverture sigmoïdienne, oreillette gauche

Fonction ventriculaire gauche

- Analyse segmentaire



Segment level	AS	Ant	Ant Lat	Post Lat	Inf	IS
Basal	1	2	3	4	5	6
Mid	7	8	9	10	11	12
Apical	13	14	15	--	16	13

- Ref Roberto Lang 2006, recommandation for chamber quantification