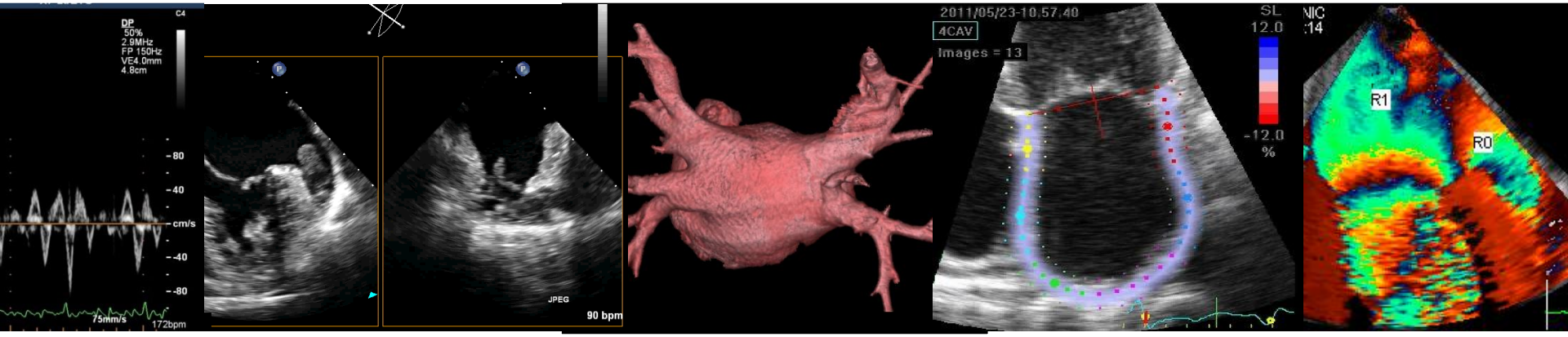
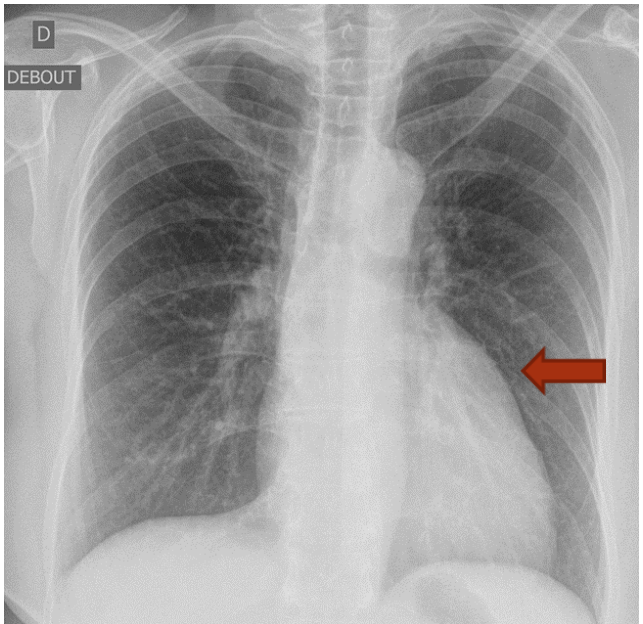
Atrial Fibrillation
Atrial Stunning in Echo

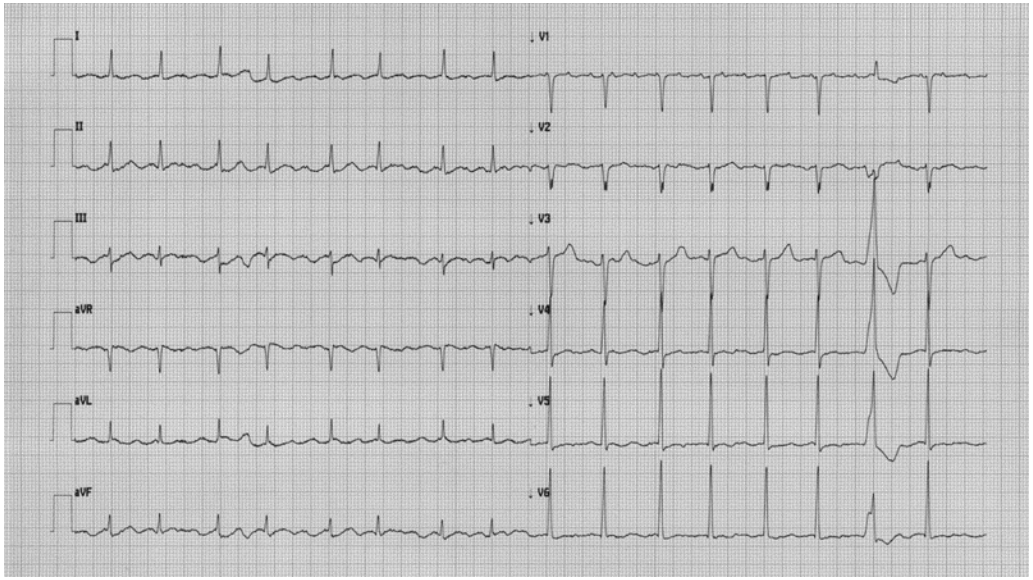
Erwan DONAL,
Cardiologie, CHU Rennes, France
erwan.donal@chu-rennes.fr



A Case Report

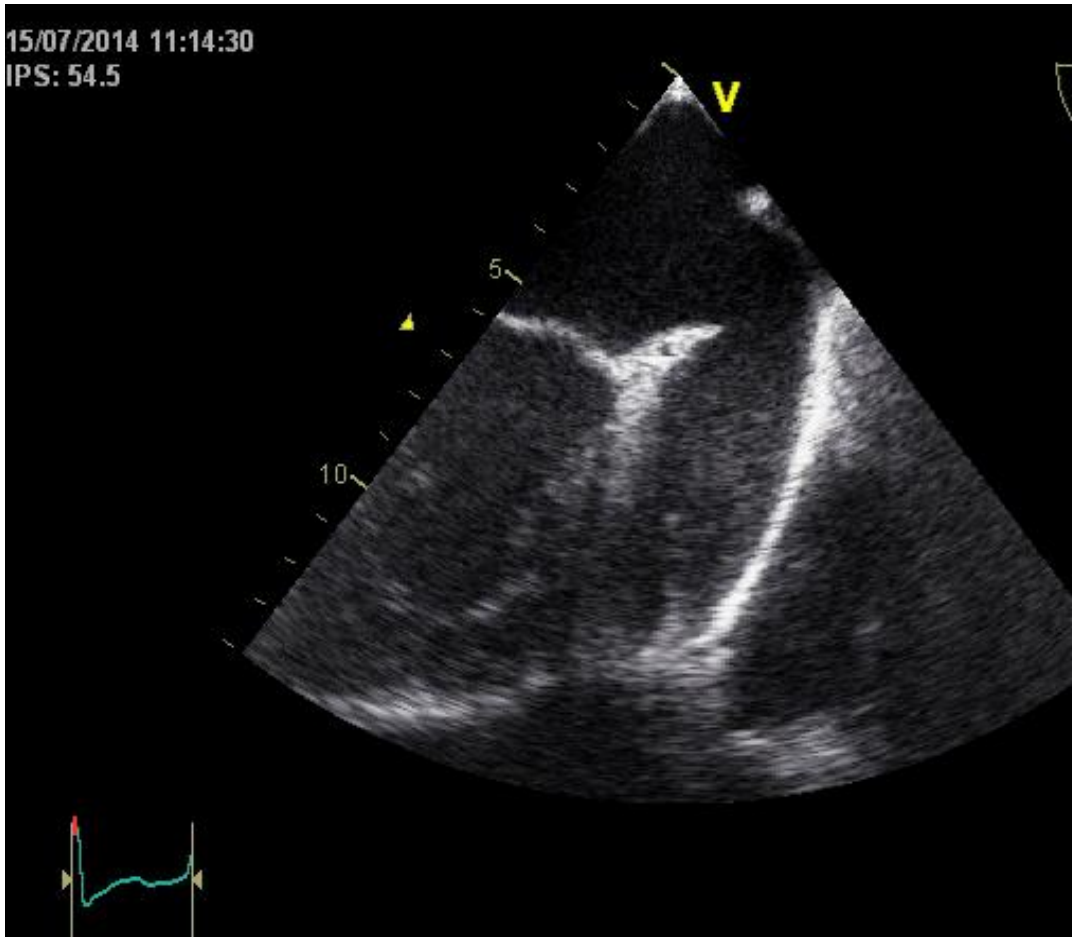
- Miss H, 64 year old
- Medical background: only hypertension
- First hospitalization for palpitations and dyspnea,
- initially rapid Afib





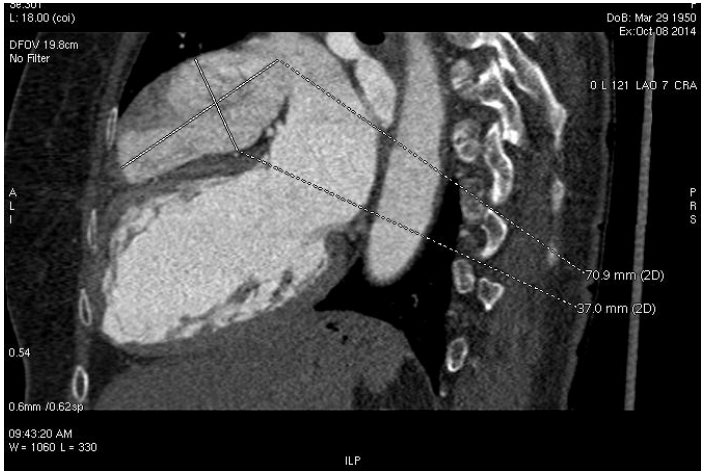
Symptoms and rapid Afib >> TEE

- **Very large LAA 17 cm2**
- **SEC and low emptying flow velocities**
- **OK for a cardioversion**

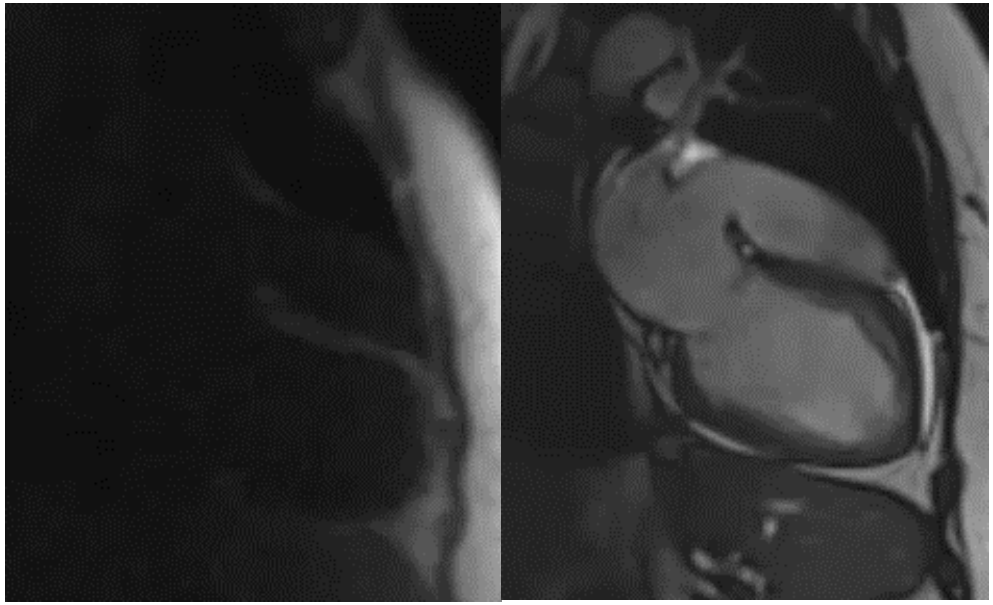


- Cardioversion >>> Sinus rhythm >>> back home BUT
- ACUTE PULMONARY OEDEMA <u>after less than 2 days at home</u>

Cardiac CT

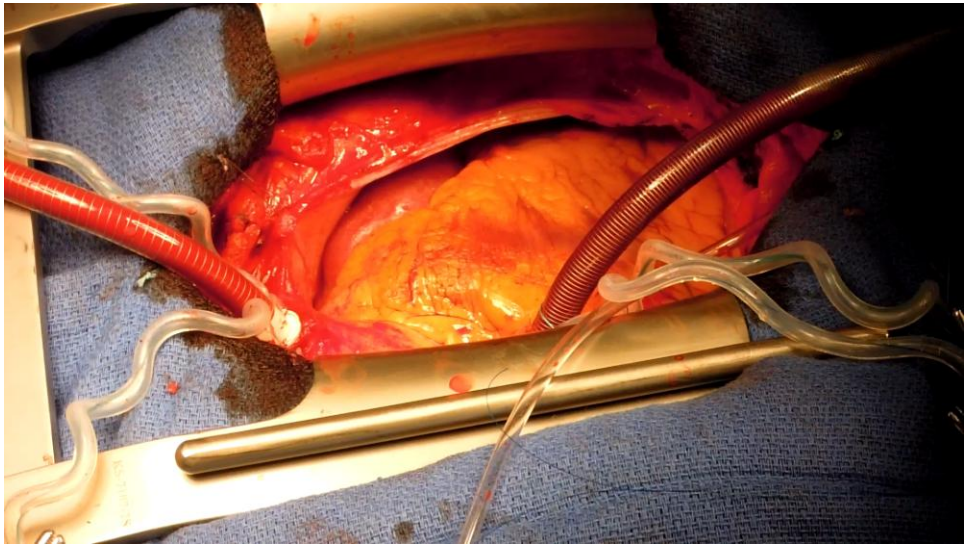


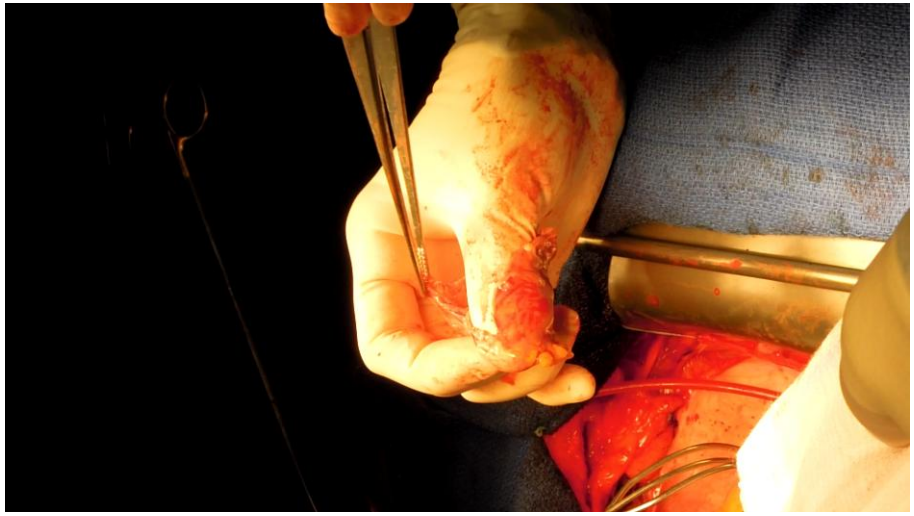
CRM



- Cardiac CT: thrombus in a very large LAA
- CRM= no thrombus

Multi-disciplinary decision of a surgical extraction of the LAA





Role of Echocardiography in the Management of Atrial fibrillation patients : rather limited according to guidelines

Thrombo-embolic risk evaluation based on : CHA_2DS_2VASC

- Echocardiography required for assessing the presence of a LV dysfunction

But:

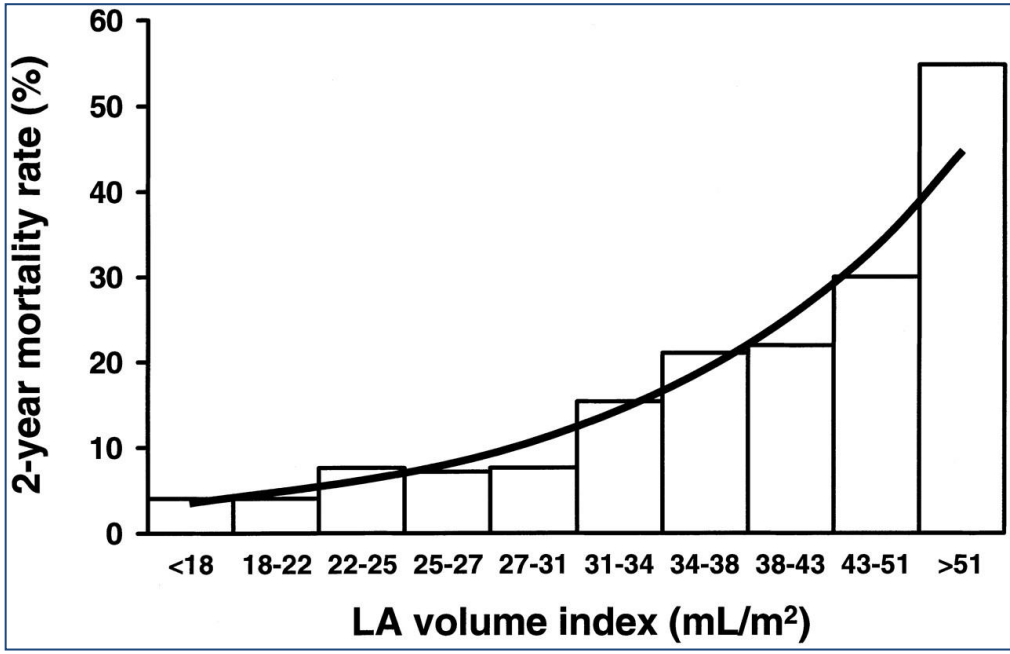
- No recommandation about the LA size or LA function

Wheeler et Masani. EJE 2011; 12: i33.
Camm et al. ESC guidelines for the management of atrial fibrillation. Eur Heart J 2010 and 2012; 33: 2719-47.

LA SIZE

- LA size is associated with mortality

- LA size associated with the risk of A Fib,
  - Recurrence
  - Risk of embolism



Cut-off values:

LA area > 18 cm^2/m^2

LA diameter > 16 mm/m^2

the most relevant:

→ LA volume > 34 ml/m^2

Moller et al. Circulation 2003; 107: 2207
Parkash et al. Am H J 2004; 148: 649.

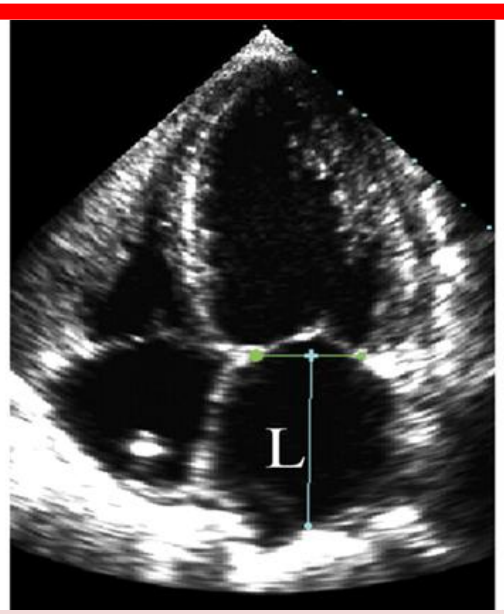
Parameters	Total Mean ± SD	Total 2 SD range	Male Mean ± SD	Female Mean ± SD	*P*-value
Parasternal long-axis view					
LA diameter, mm	33.6 ± 4.3	26.7–41.0	35.1 ± 4.1	32.4 ± 4.1	<0.001
Apical views					
Apical four-chamber view					
LA minor length, mm	39.2 ± 4.7	31.0–47.5	40.1 ± 4.5	38.5 ± 4.8	0.001
LA major length, mm	47.6 ± 5.5	38.5–57.0	48.8 ± 5.4	46.6 ± 5.4	<0.001
LA area, cm^2	16.5 ± 3.2	11.5–21.9	17.2 ± 3.1	15.8 ± 3.1	<0.001
Normalized to BSA					
Parasternal long-axis view					
LA diameter, mm/m^2	18.7 ± 2.4	15.0–22.8	18.1 ± 2.3	19.2 ± 2.4	<0.001
Apical views					
Apical four-chamber view					
LA area, cm^2/m^2	9.1 ± 1.6	6.5–11.8	8.9 ± 1.5	9.3 ± 1.7	0.008
LA volume area-length, mL/m^2	27.1 ± 7.5	14.9–40.3	27.0 ± 7.0	27.3 ± 7.9	0.733
LA volume Simpson, mL/m^2	24.8 ± 6.8	13.7–36.9	24.5 ± 6.4	25.1 ± 7.2	0.462
Apical two-chamber view					
LA area, cm^2/m^2	9.5 ± 1.5	7.1–12.1	9.3 ± 1.6	9.6 ± 1.4	0.126
LA volume area-length, mL/m^2	28.3 ± 7.8	17.5–43.1	28.9 ± 8.5	28.0 ± 7.3	0.263
LA volume Simpson, mL/m^2	26.6 ± 7.2	16.1–40.1	27.1 ± 7.9	26.1 ± 6.7	0.189
Biplane					
LA volume area-length, mL/m^2	28.6 ± 6.7	19.3–41.5	28.9 ± 7.0	28.3 ± 6.5	0.376

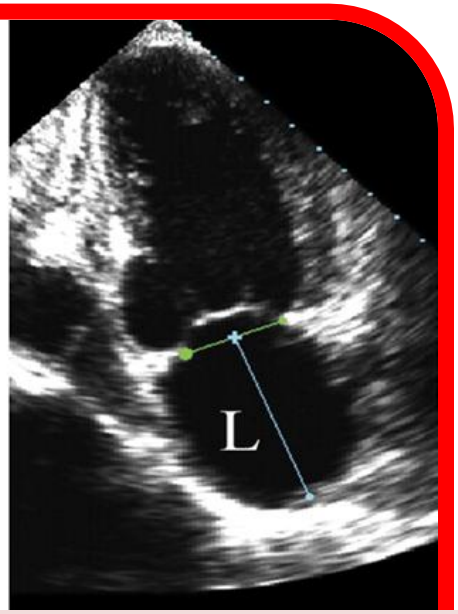
Kou et al. NORRE study. EHJcvim 2014; 15, 680–69

Left Atrial Volume =

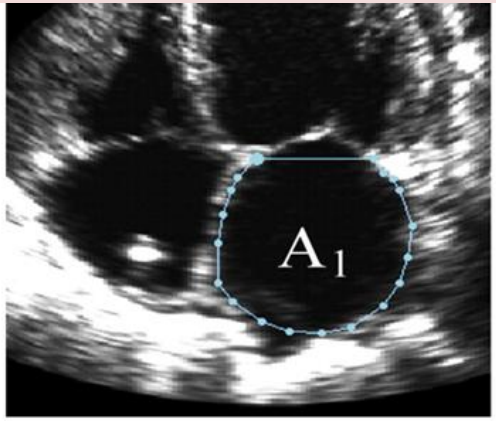
$$8/3\pi[(A_1)(A_2)/(L)]^{*}$$

* (L) is the shortest of either the A4C or A2C length

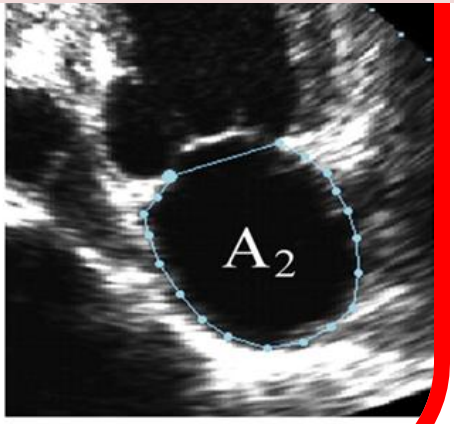




LA volume (ml)	22–52	53–62	63–72	≥73
LA volume/BSA (ml/m^2)	**22±6**	**29–33**	**34–39**	**≥40**

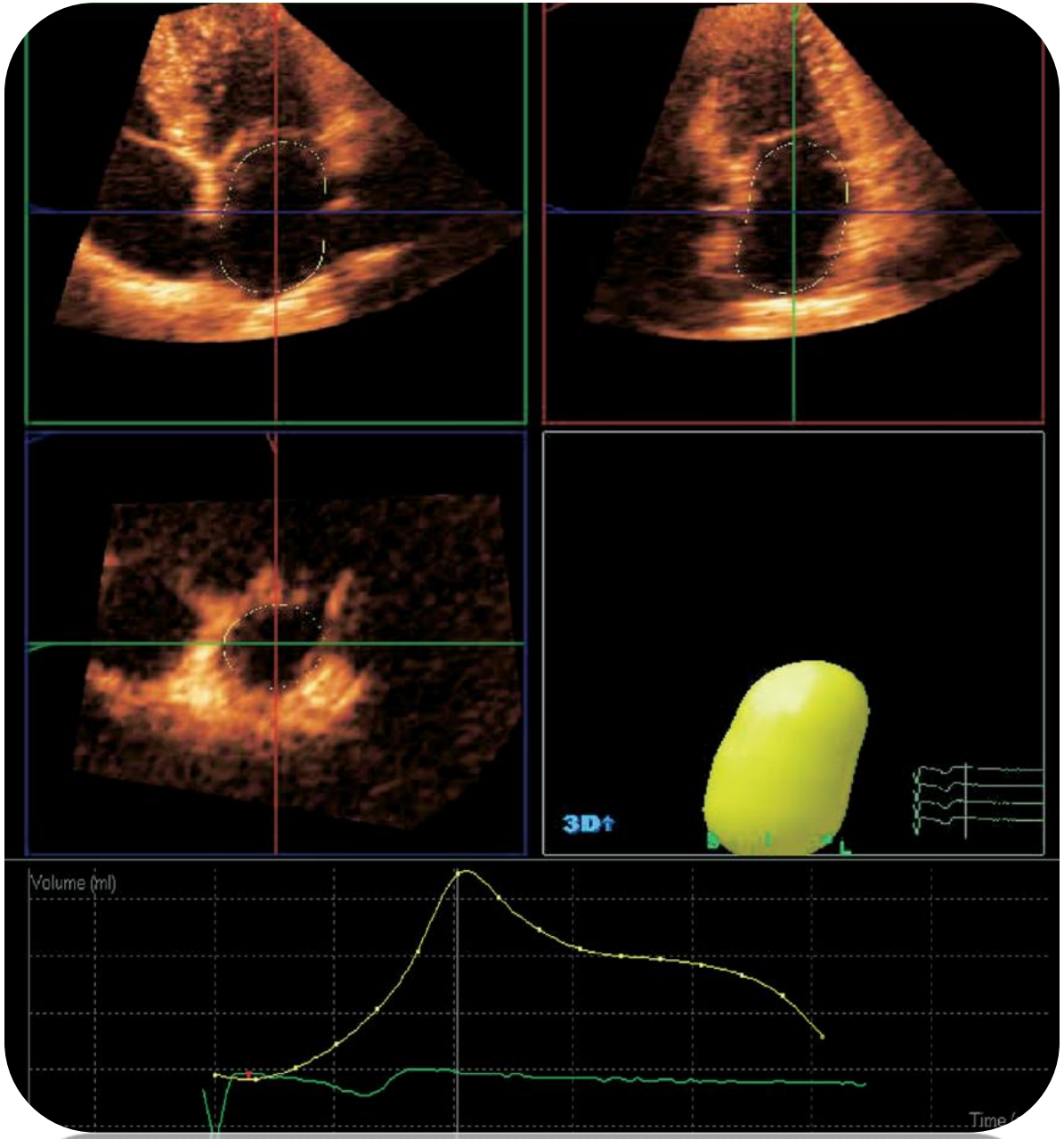


A4C



A2C

Lang R M et al. Eur J Echocardiogr 2006;7:79-108



in patients who maintain sinus rhythm after RF, a significant reverse remodeling and functional improvement of the left atrium is observed using RT3DE

Marsan et al. Am J Cardiol 2008

Left atrial Appendage >> TEE

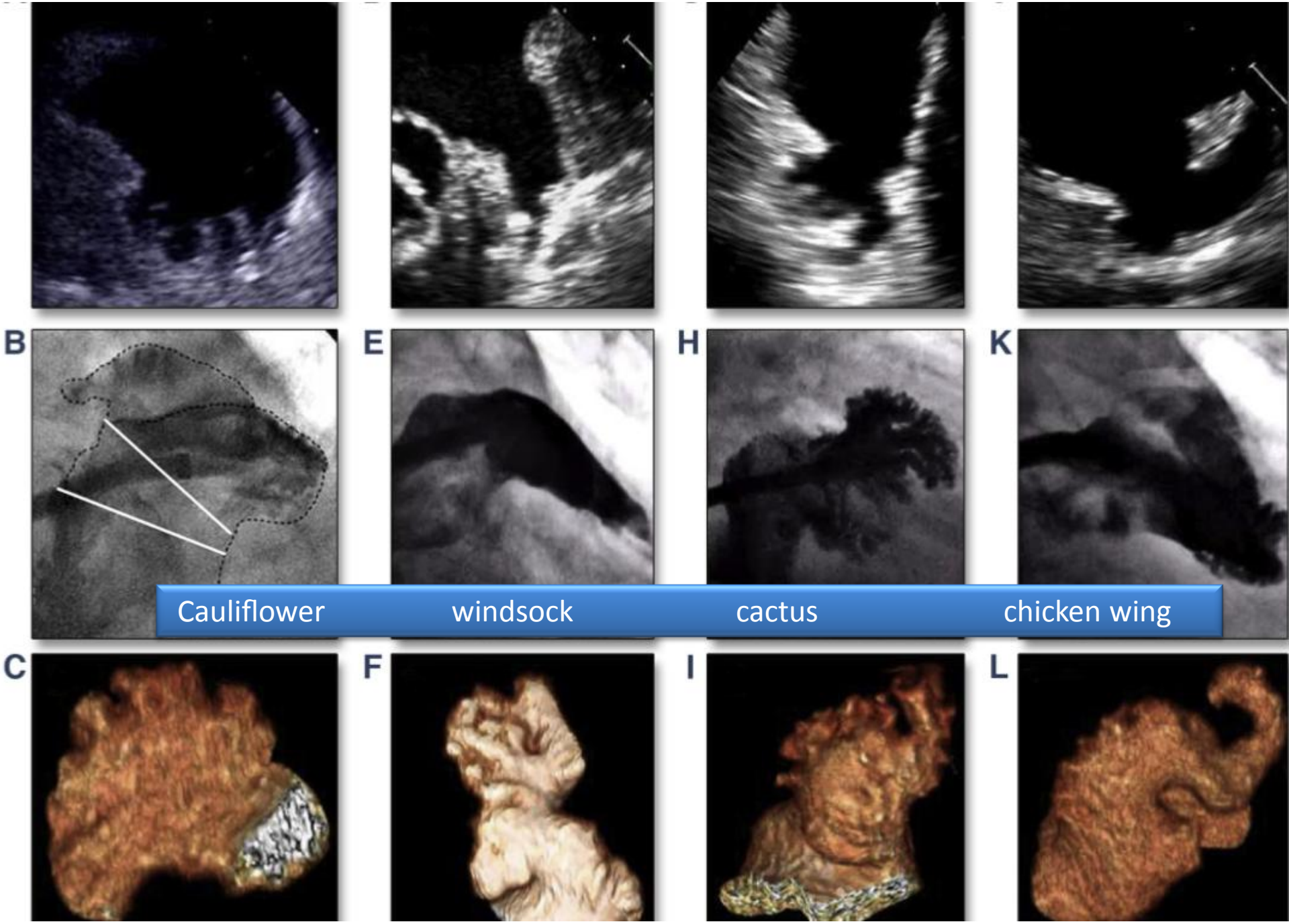
Acute –study : 1222 patients: security & feasibility of the cardioversion after TEE checking fot the absence of thrombus / cardioversion after > 3 weeks of effective anticoagulation.

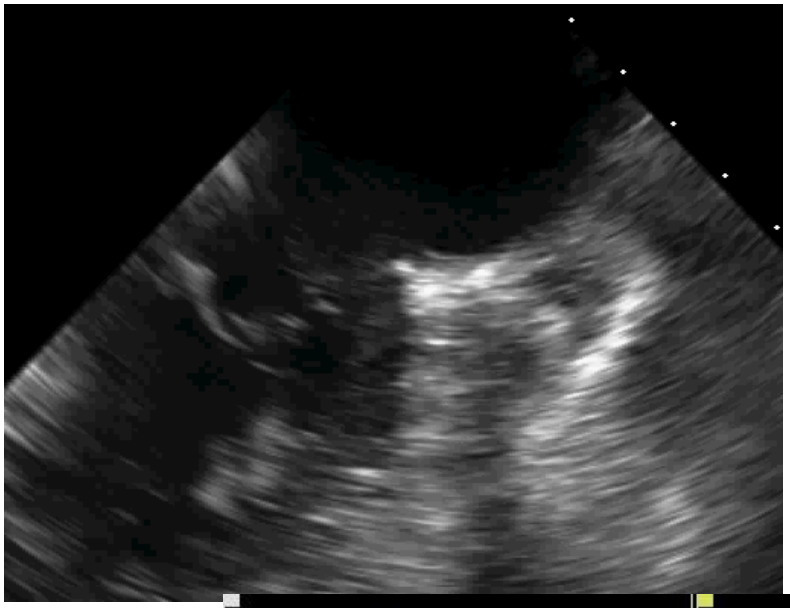
13.8 % thrombi in Afib > 48h in that study

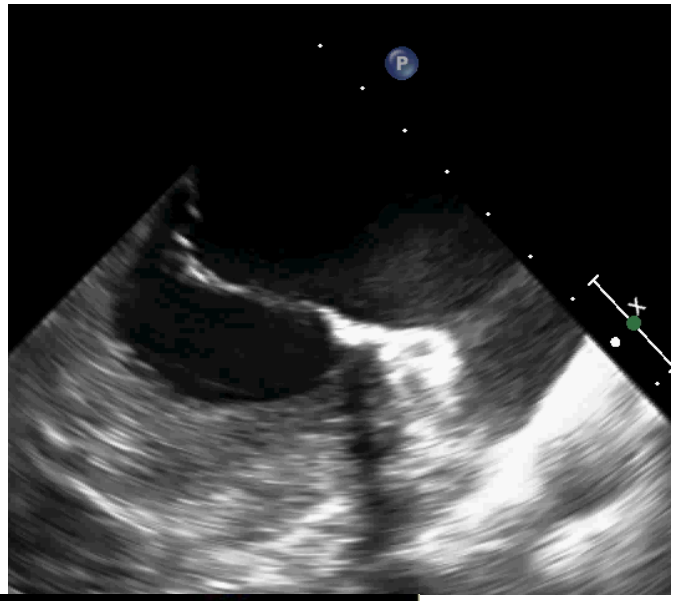
Klein et al. N Engl J Med 2001; 344: 1411

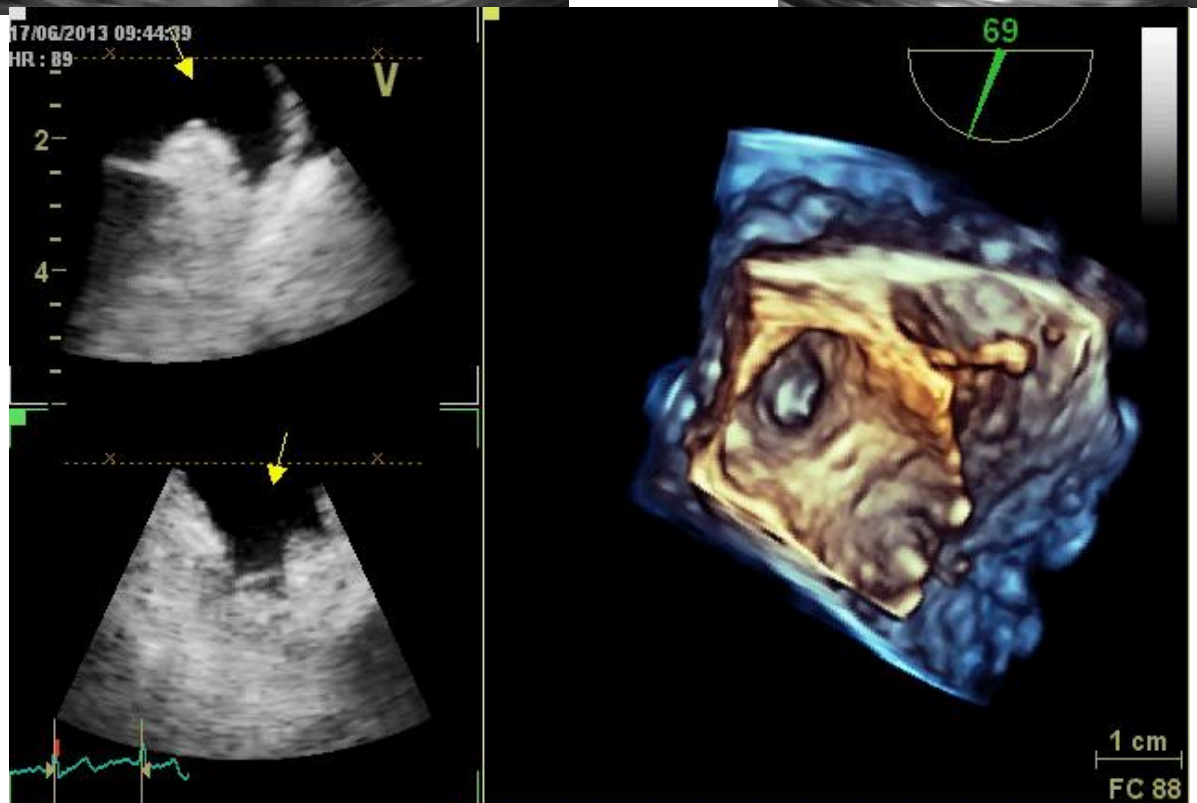
Nowadays +-7%

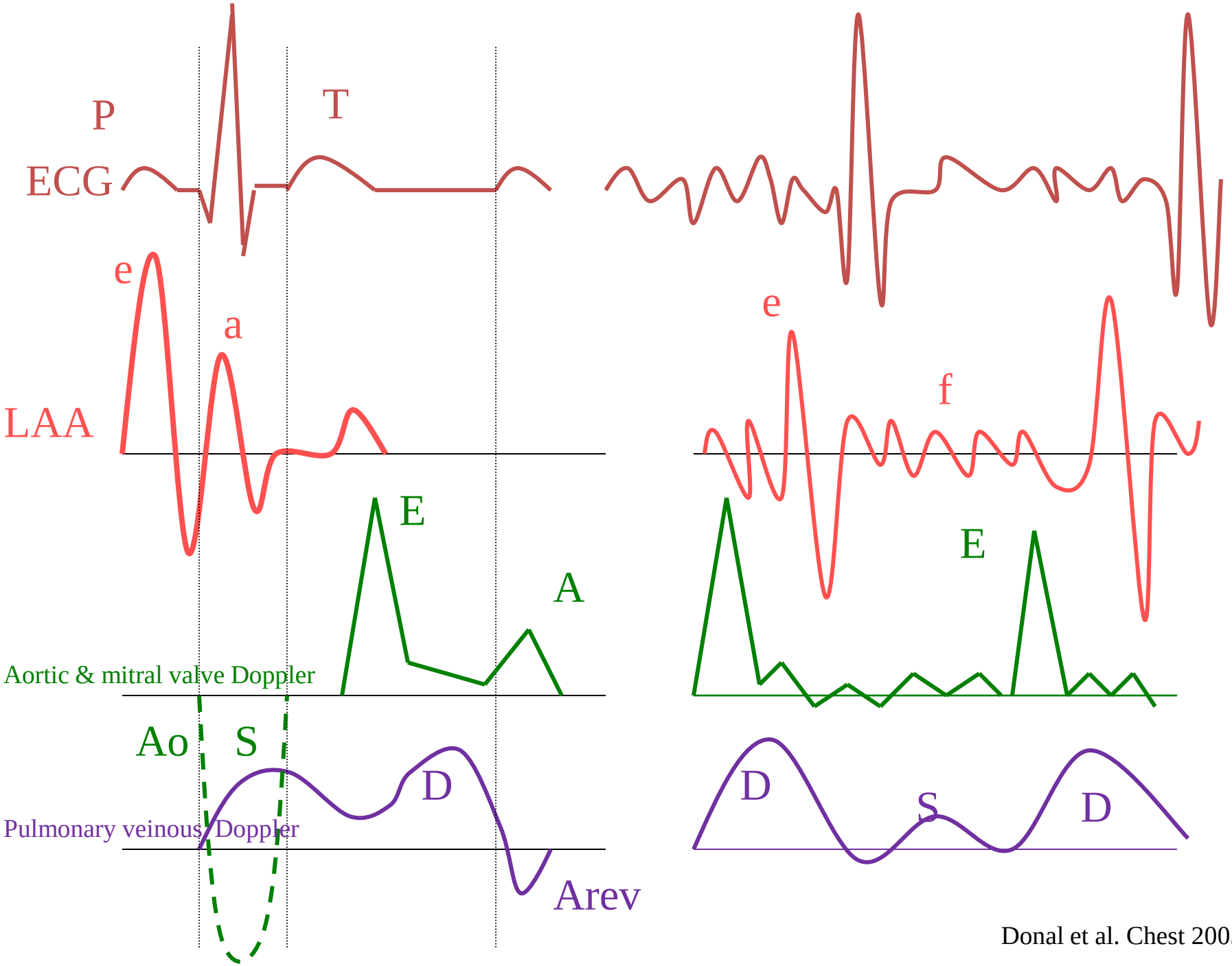
Different LAA morphologies.
(A) Chicken wing.
(B) Windsock.
(C) Cauliflower.
(D) Cactus


B
E
H
K
Cauliflower
windsock
cactus
chicken wing
C
F
I
L



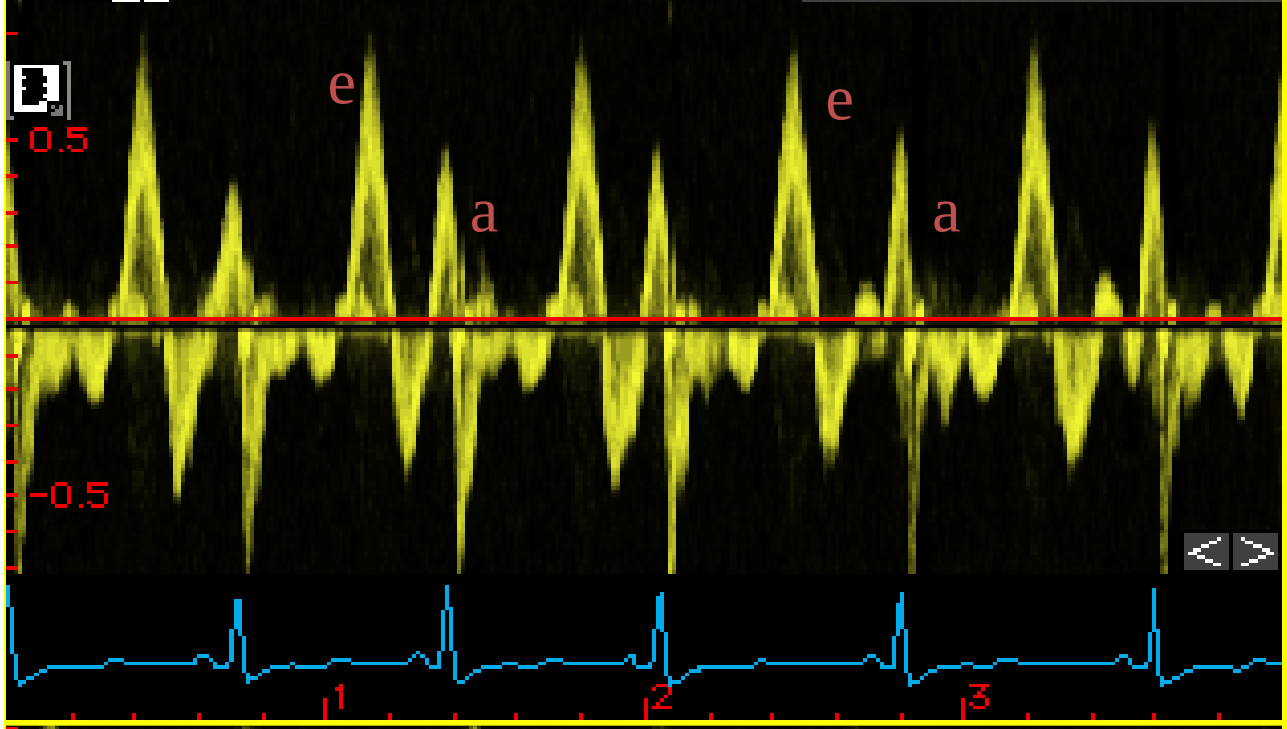

P


17/06/2013 09:44:39
HR : 89
V
2
4
69
1 cm
FC 88

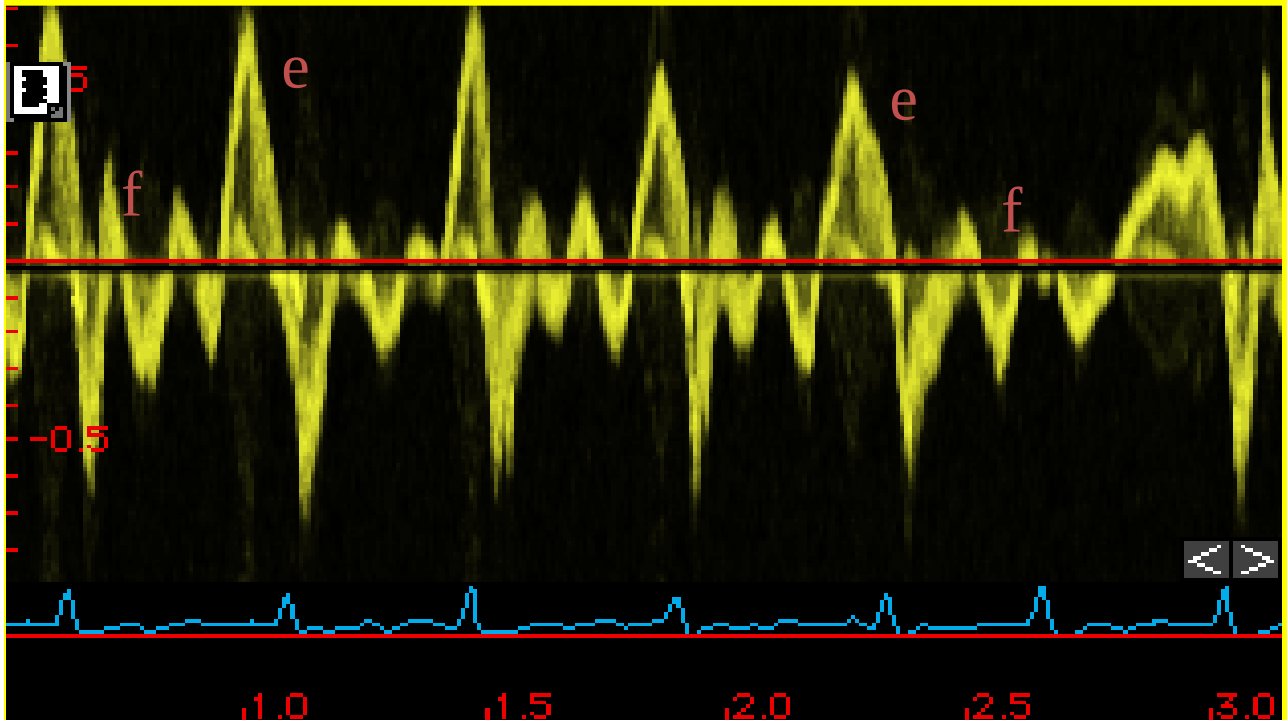


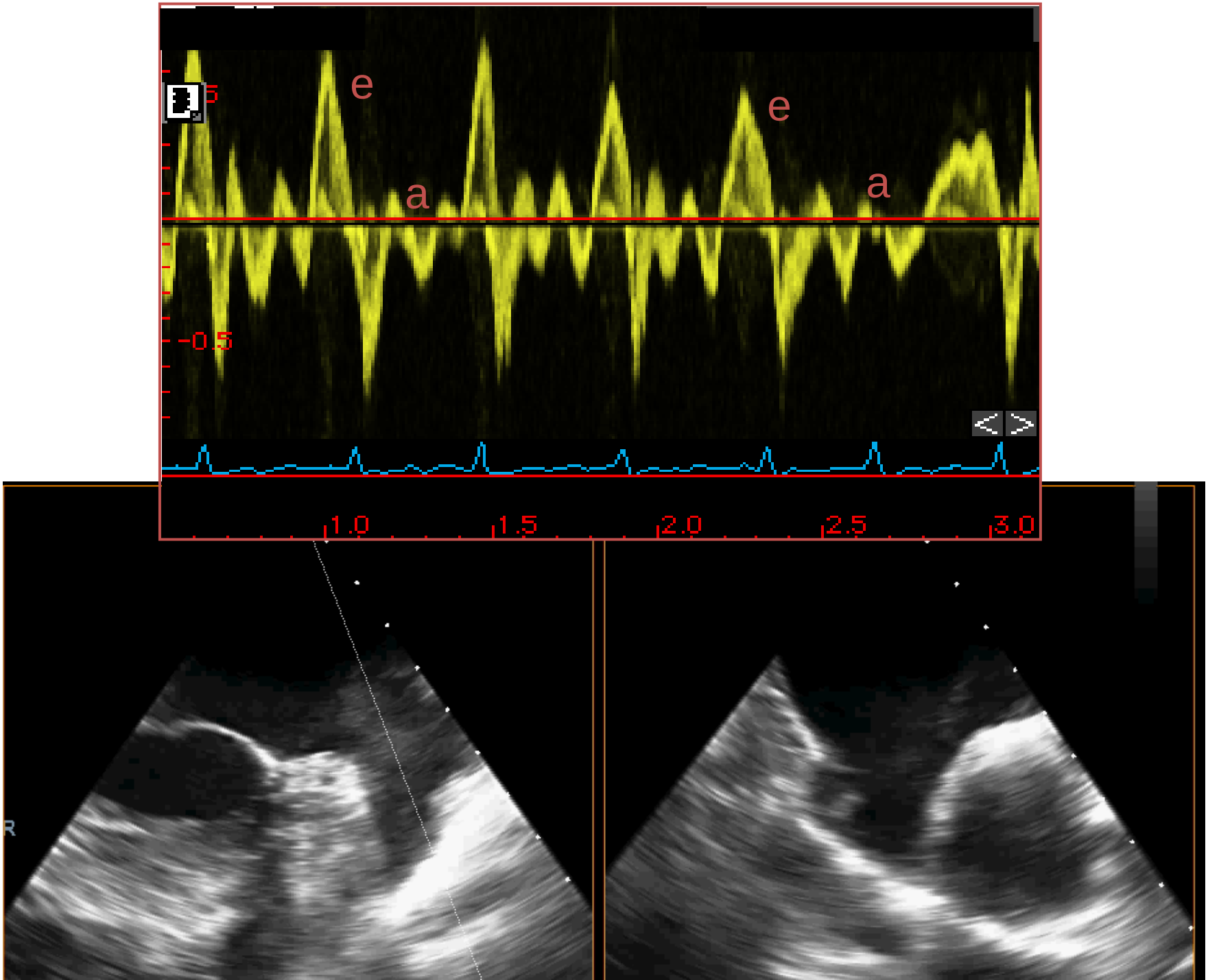
Donal et al. Chest 2005

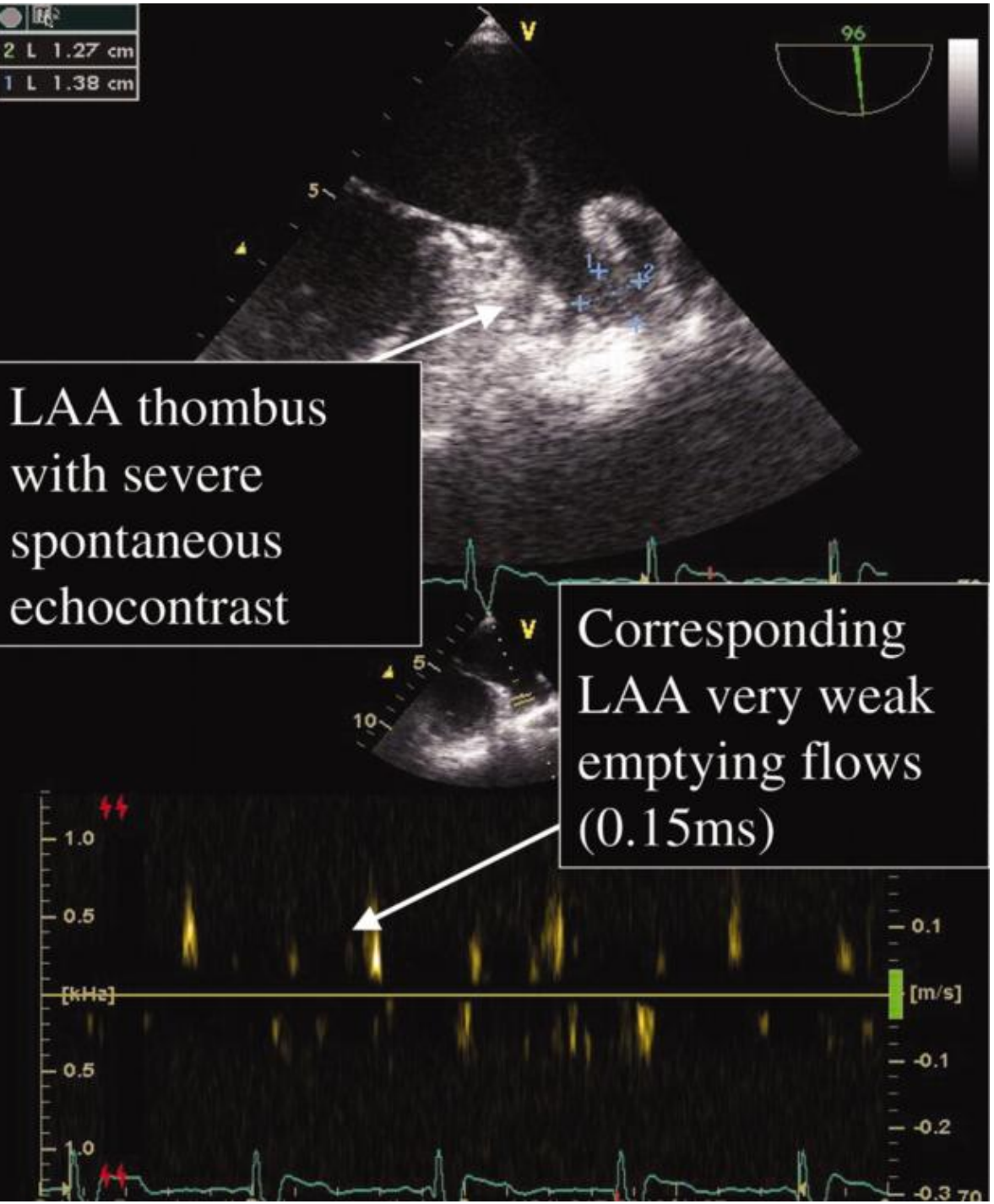
Rythme Sinusal

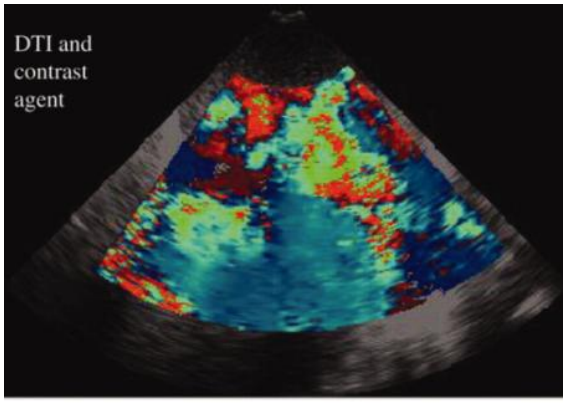


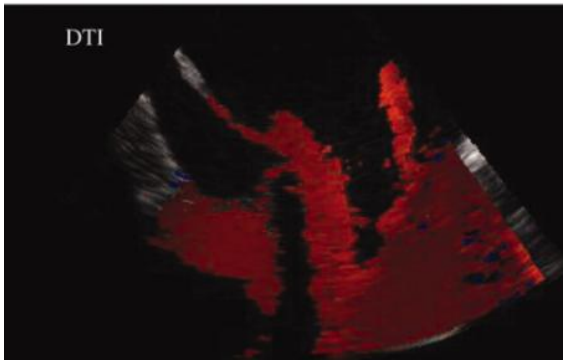
Fibrillation Atriale

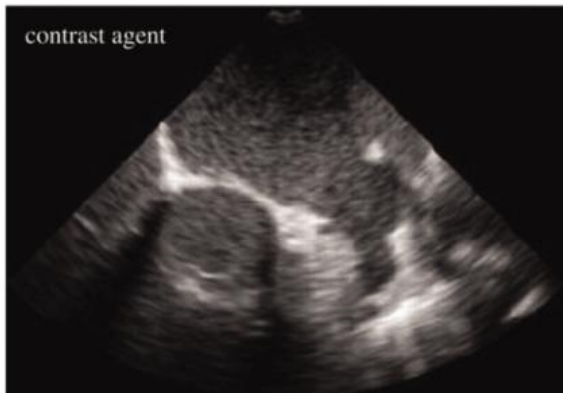



e
a
e
a
-0.5
1.0
1.5
2.0
2.5
3.0



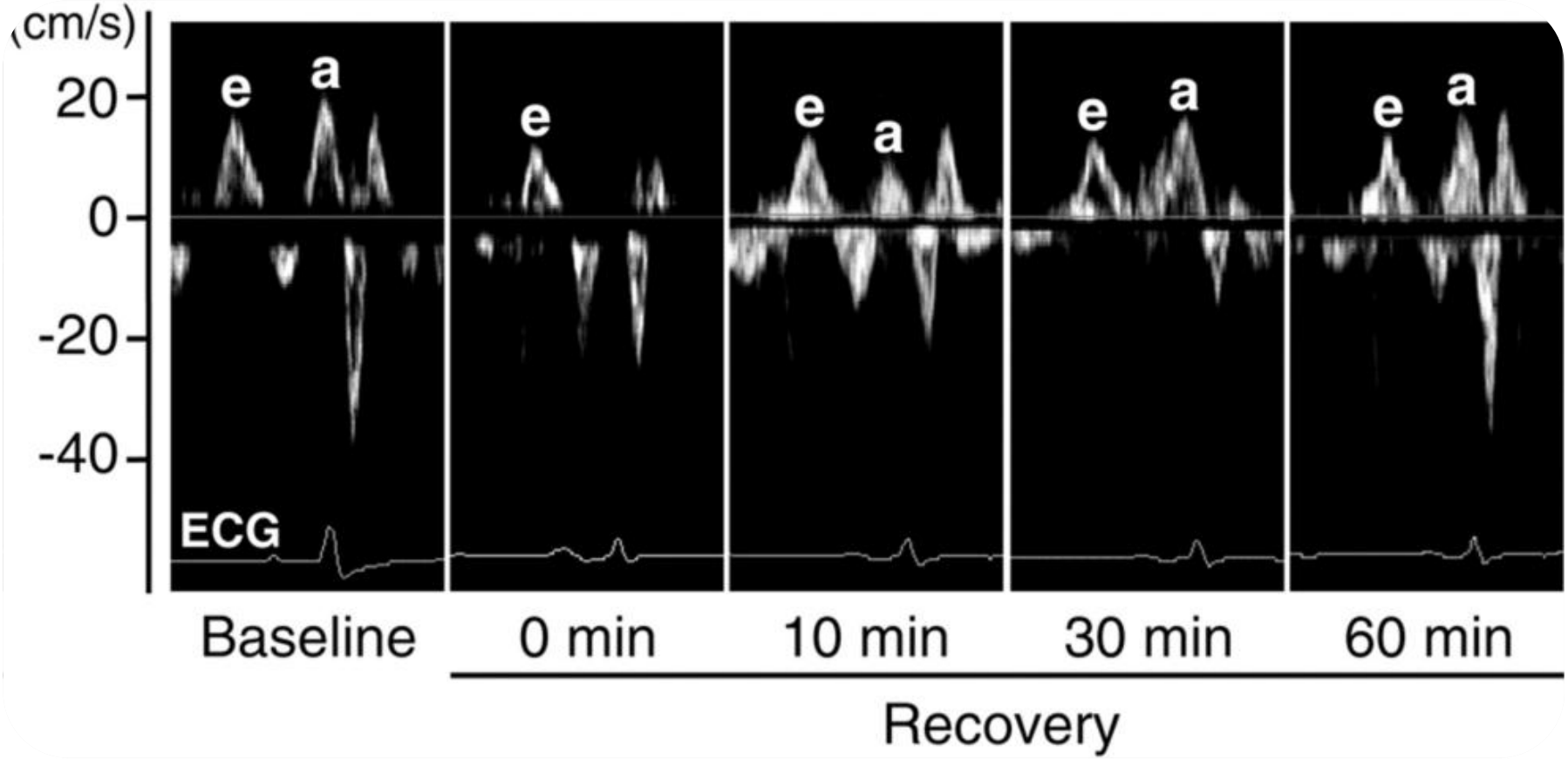






Donal et al. EJE 2007

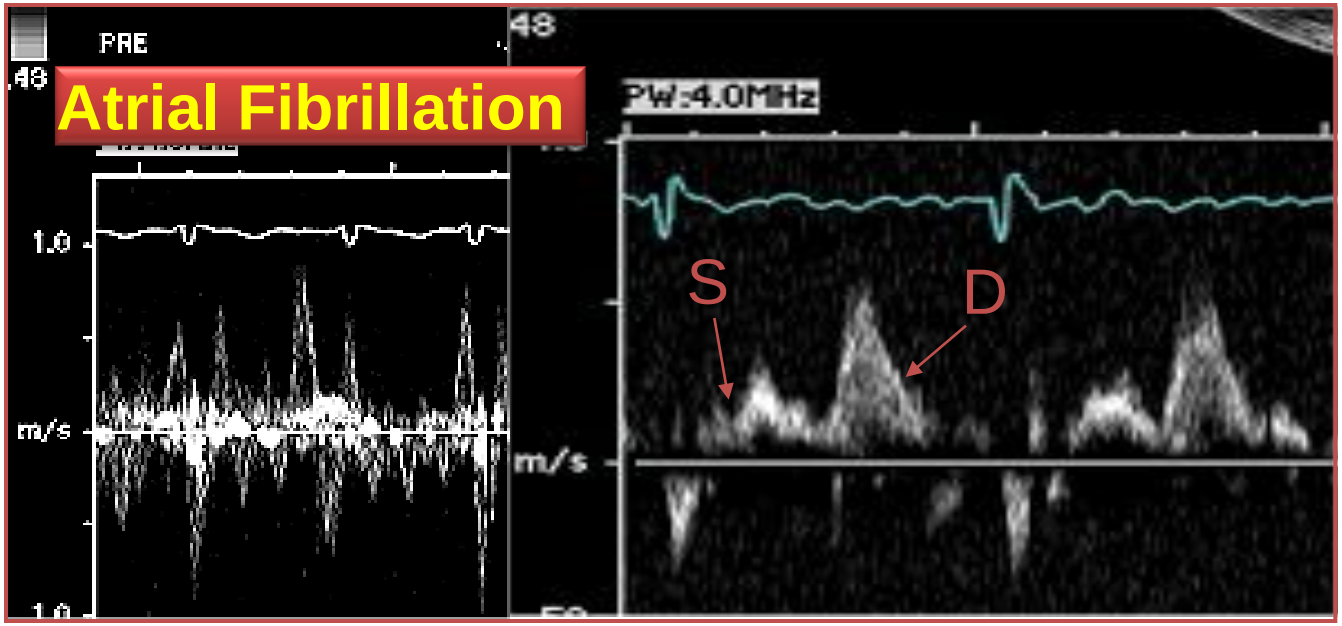
In an animal model; difficult to monitor the stunning in the human being…



Donal et al. Chest 2005

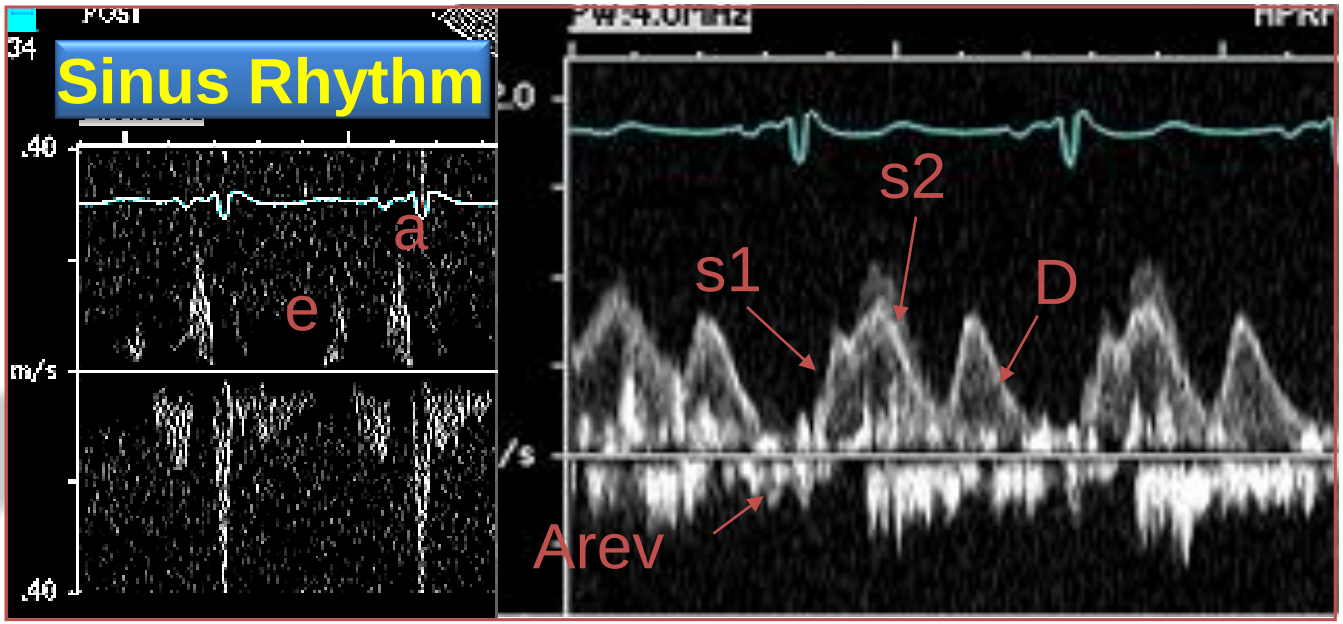
Atrial Fibrillation

LAA & PVF



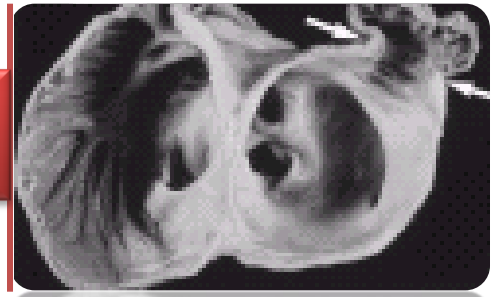
Sinus Rhythm

↑ S (pvf)
(reservoir function)
& weak A rev
(atrial booster pump function)



Donal et al. Am J Cardiol 2005

Atrial Stunning



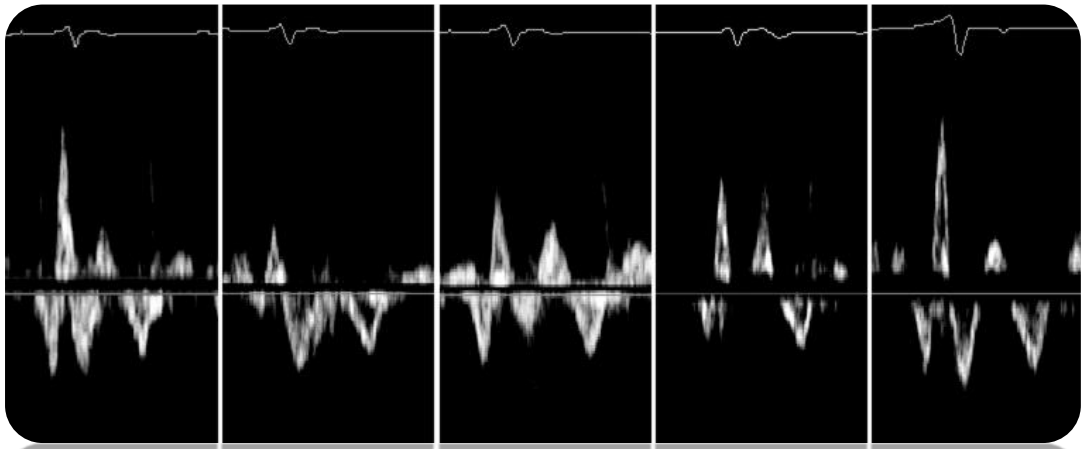
Logan et al (Lancet 1965; ii: 471):
description of the absence of A wave of the LA pressure recording after a cardioversion (« stunning »)

Manning et al (JACC 1994; 23:1535):

+ longer is the Afib, longer is the stunning and the weakness of LA systolic function

(24h pour ≈ 2 sem. vs > 1mois pour une durée > 6 sem)

"stunning" : intra myocardial cells calcium overload



CARDIOVASCULAR MEDICINE

Acute improvement of atrial mechanical stunning after electrical cardioversion of persistent atrial fibrillation: comparison between biatrial and single atrial pacing

M Takagi, A Doi, N Shirai, K Hirata, Y Takemoto, K Takeuchi, J Yoshikawa

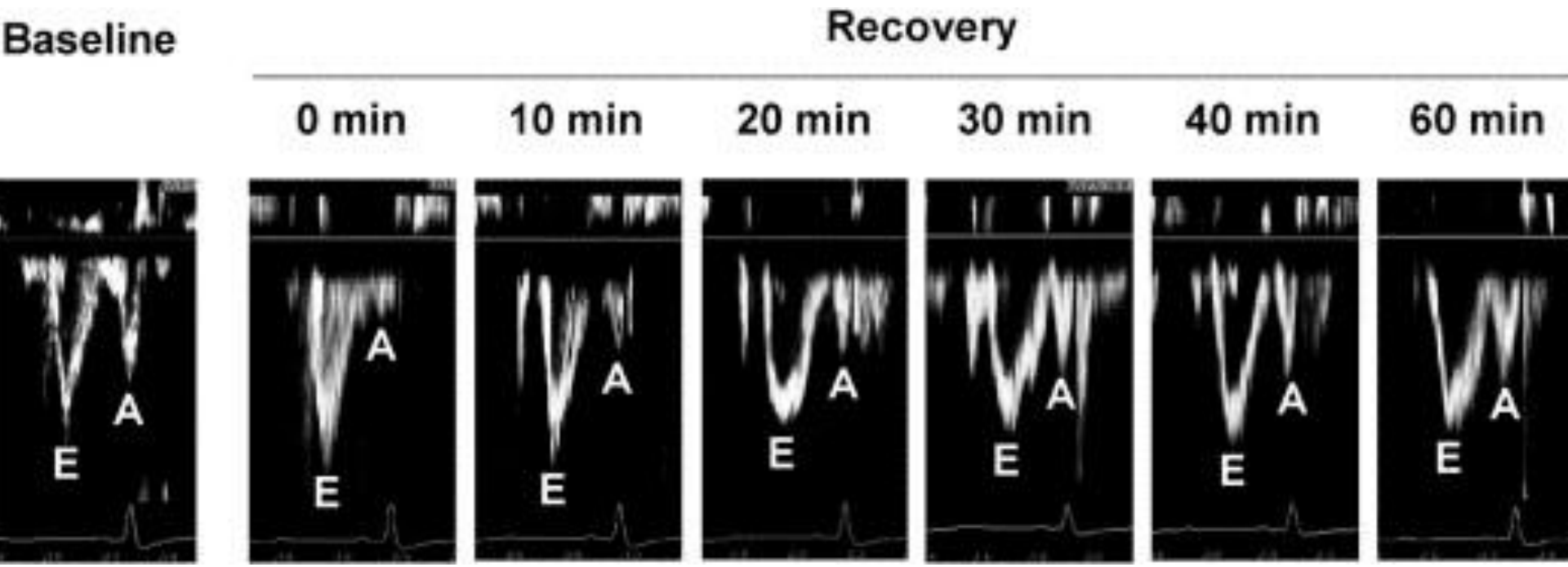
Heart 2005;**91**:58–63. doi: 10.1136/hrt.2003.032334

See end of article for authors' affiliations

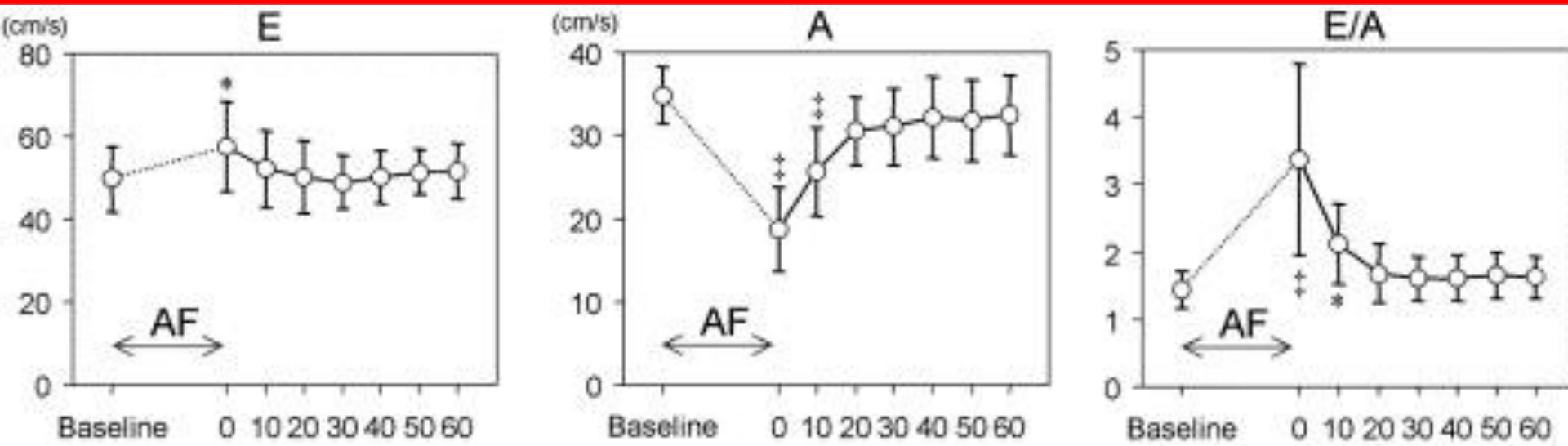
Correspondence to: Dr Masahiko Takagi, Department of Internal Medicine and Cardiology, Osaka City University Graduate School of Medicine, 1-4-3 Asahimachi, Abeno-ku, Osaka 5458585, Japan; m7424580@msic.med.osaka-cu.ac.jp

Accepted 2 April 2004

Objective: To evaluate the acute effects of atrial pacing at different pacing sites on mechanical stunning after cardioversion of atrial fibrillation (AF).
Setting: Tertiary referral centre.
Patients: 20 patients with persistent AF were studied.
Interventions: Spontaneous echo contrast (SEC), left atrial appendage emptying velocity (LAAEV), and left atrial appendage emptying fraction (LAAEF) were assessed by transoesophageal echocardiography (TOE) during AF, after conversion to sinus rhythm, and during atrial pacing from the right atrial appendage, left lateral atrium, and both atria simultaneously. Transmitral inflow velocity of the atrial wave (TMIF-A) by TOE and the maximum P wave duration in 12 lead ECG were also measured during sinus rhythm and atrial pacing.
Main outcome measures: Comparison of atrial mechanical function and P wave duration in 12 lead ECG during atrial pacing from different sites after cardioversion of AF.
Results: Compared with sinus rhythm, atrial pacing at 80 beats/min increased LAAEV from mean (SD) 14.6 (10.1) to 33.4 (19.8) cm/s ($p = 0.001$), LAAEF from 13.8 (8.5) to 32.1 (11.2)% ($p < 0.001$), and TMIF-A from 24.6 (11.9) to 45.6 (21.0) cm/s ($p < 0.001$) and reduced SEC grade from 2.6 (1.0) to 1.6 (0.9) ($p < 0.001$). These effects had a positive force–frequency relation. Biatrial pacing produced the shortest P wave duration and resulted in the most significant improvement in atrial function (LAAEV, 33.2 (19.3) *v* 53.7 (23.9) cm/s, $p = 0.0001$; LAAEF, 31.9 (11.1) *v* 46.2 (12.6)%, $p < 0.0001$; TMIF-A, 37.7 (18.3) *v* 54.1 (21.2) cm/s, $p < 0.001$; SEC grade, 1.4 (1.1) *v* 0.8 (0.9), $p = 0.001$, right atrial appendage versus biatrial pacing).
Conclusions: Atrial pacing at increased rates can improve atrial mechanical function after cardioversion of persistent AF. Biatrial pacing may be the most effective technique to reverse atrial mechanical stunning.

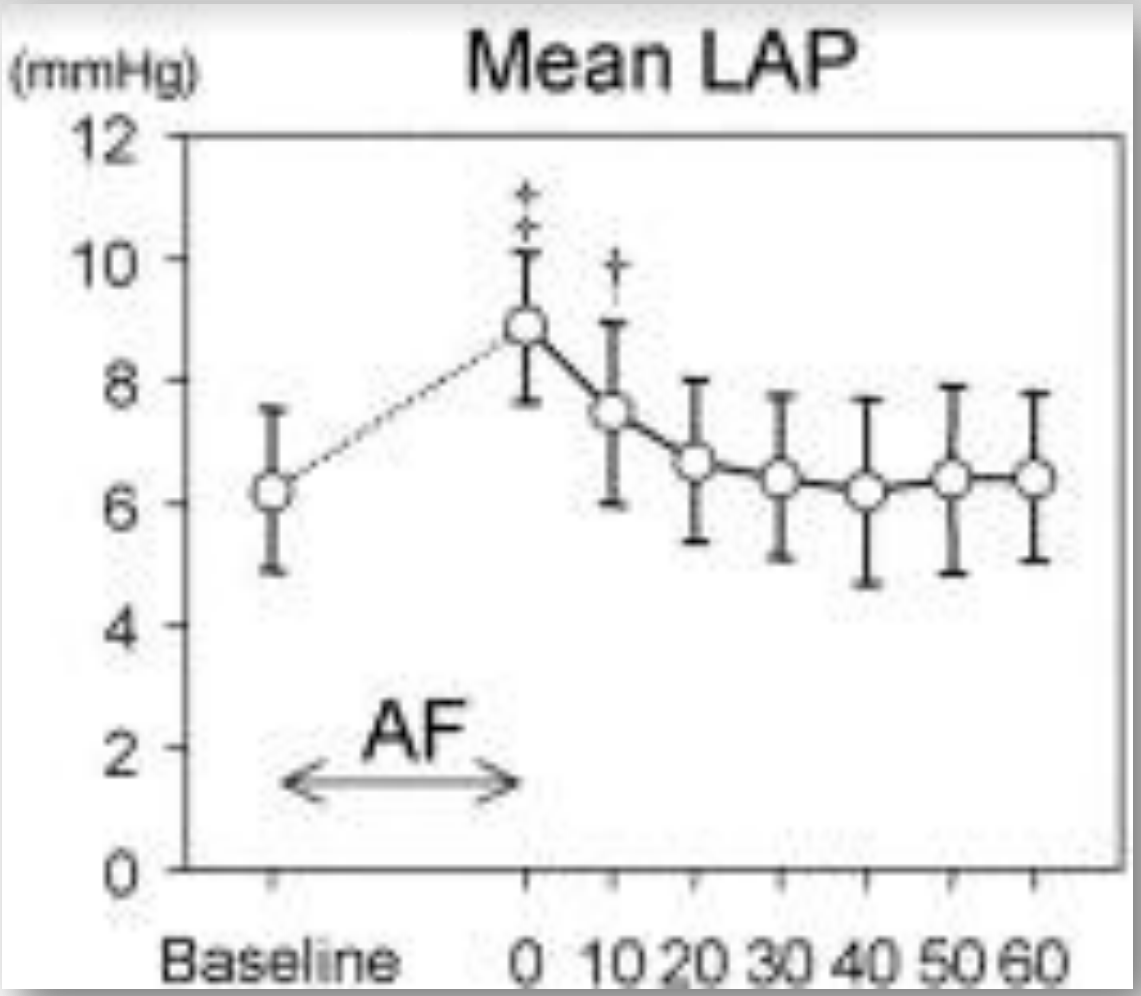


Yamada, Donal et al. J Am Soc Echocardiogr 2004 17, 813-818

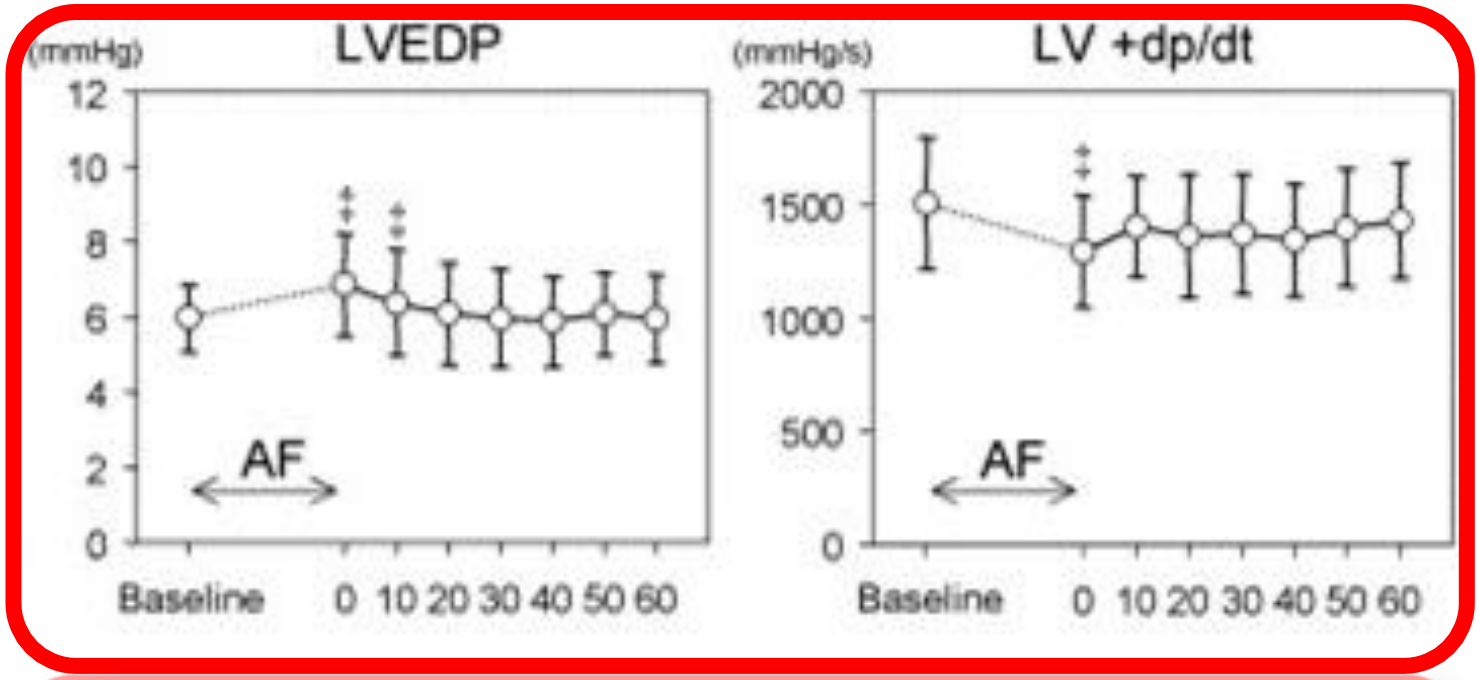


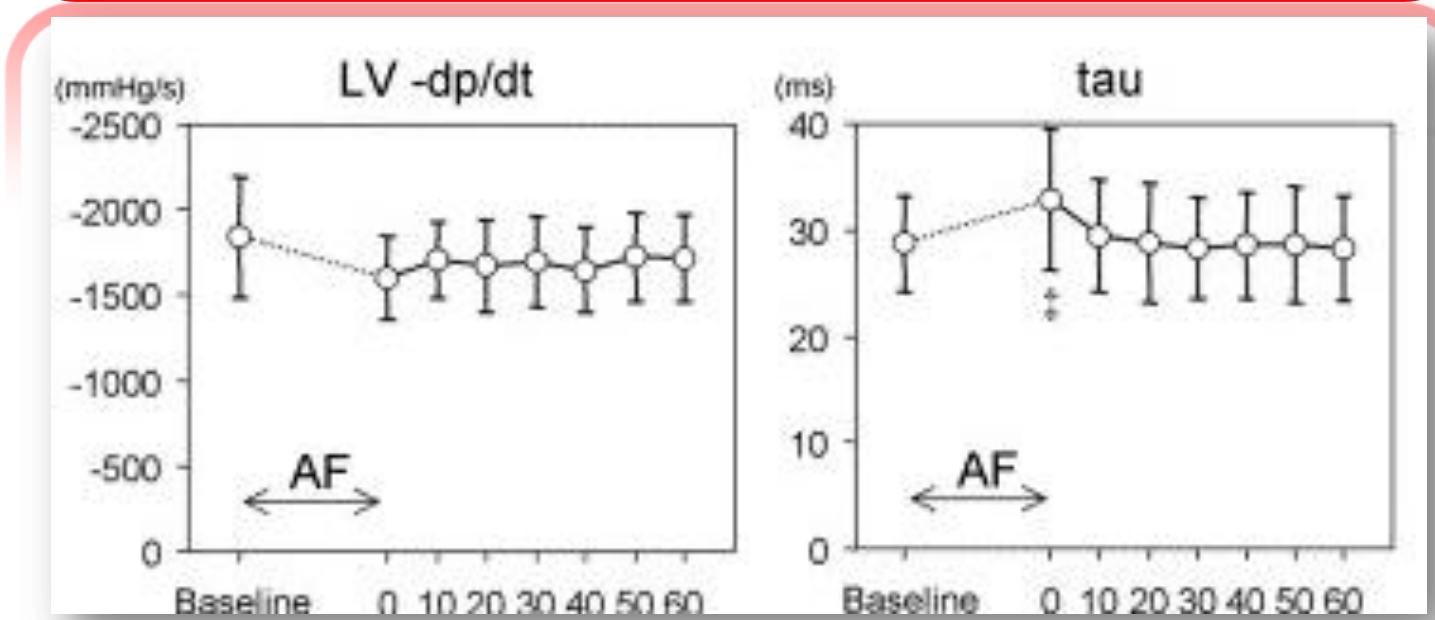
Yamada, Donal et al. J Am Soc Echocardiogr 2004 17, 813-818

After the cardioversion, there is a important increase in LA mean Pressure

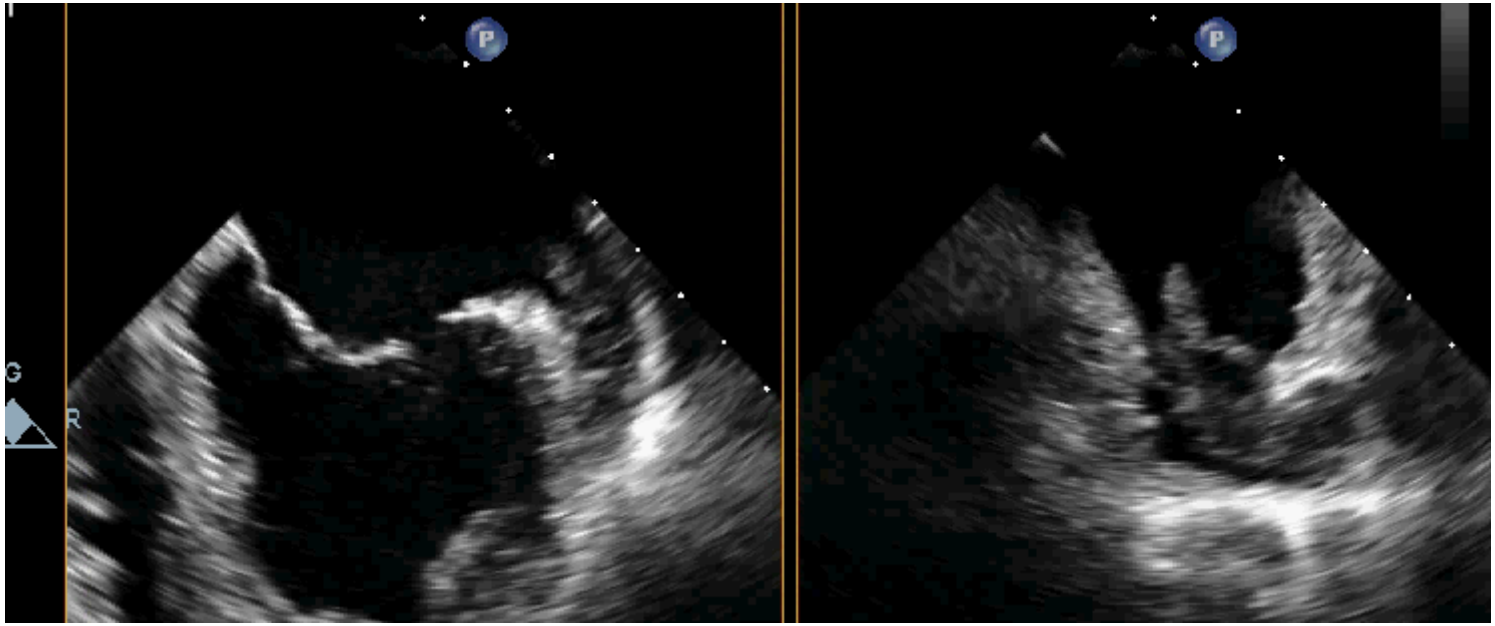


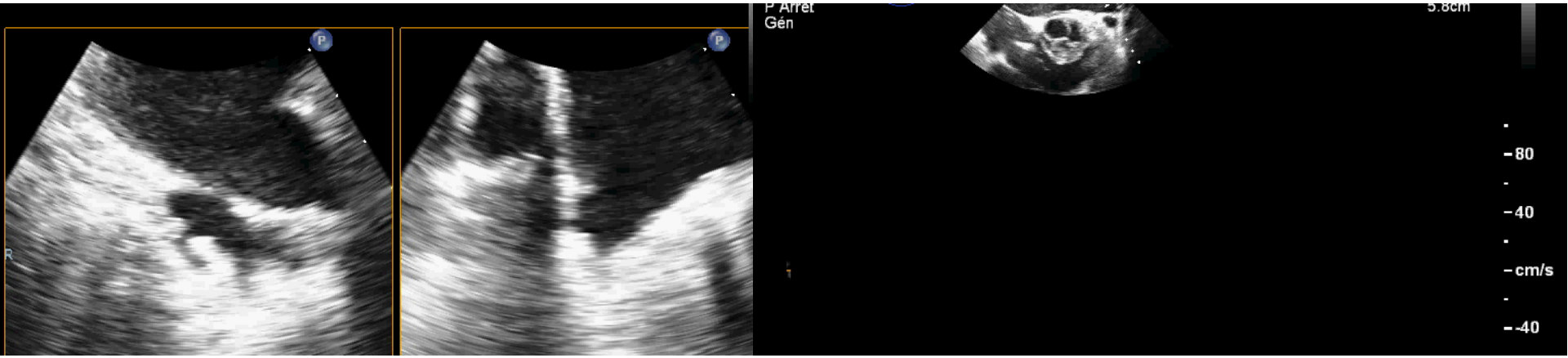
Yamada, Donal et al. J Am Soc Echocardiogr 2004 17, 813-818

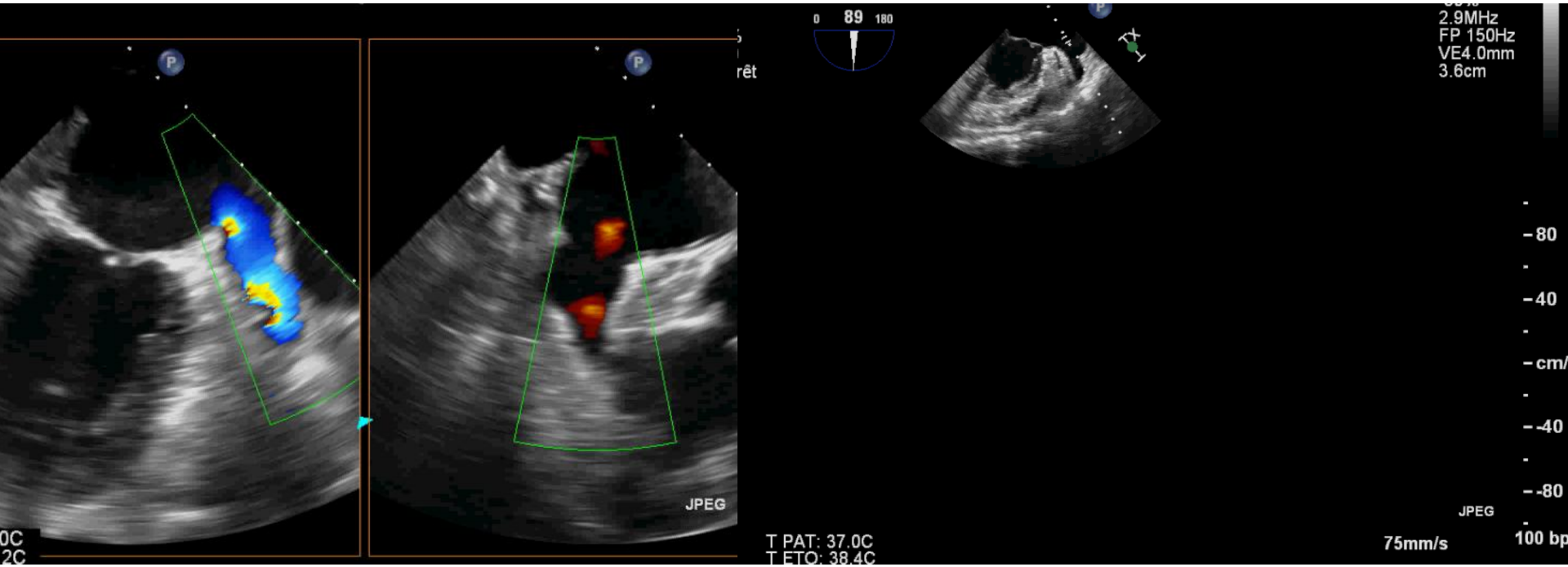




Yamada, Donal et al. J Am Soc Echocardiogr 2004 17, 813-818

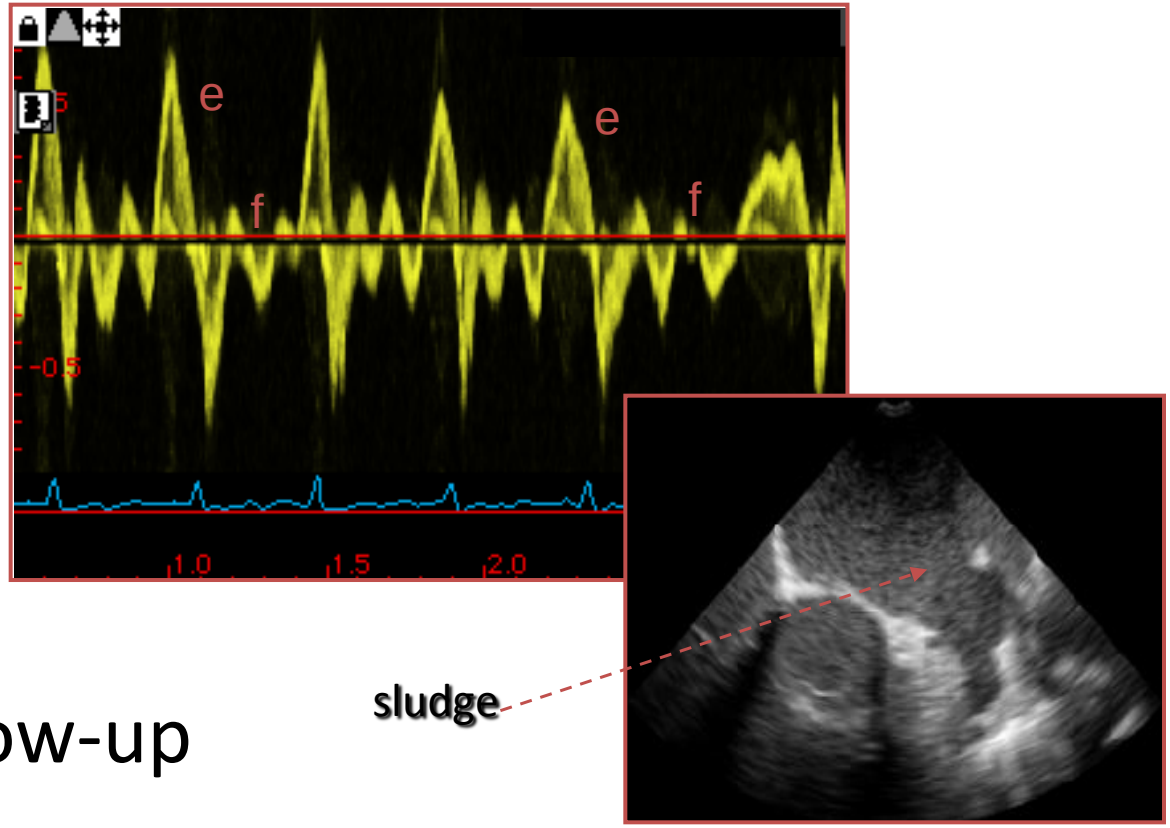

P
P
G
R


P
P
P Arrêt
Gén
5.8cm
80
40
cm/s
-40


0
89
180
2.9MHz
FP 150Hz
VE4.0mm
3.6cm
80
40
cm/
-40
-80
JPEG
JPEG
T PAT: 37.0C
T FTO: 38.4C
75mm/s
100 bp

Cardioversion success rate & LAA emptying flows recorded in AFib

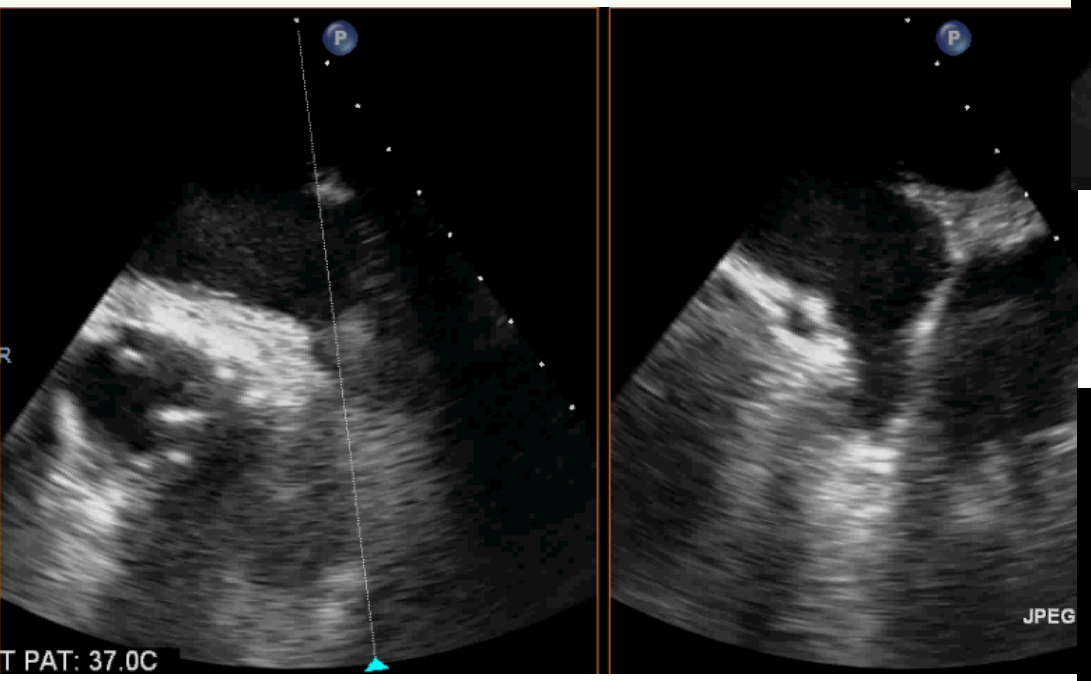
- e > 40 cm/s:
  - 56 % sensitivity
  - 80 % specificity
  - 68 % accuracy

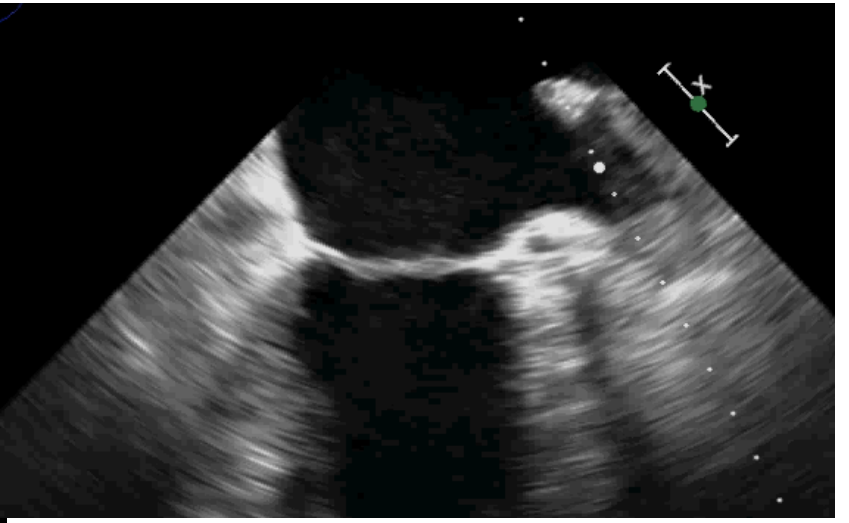


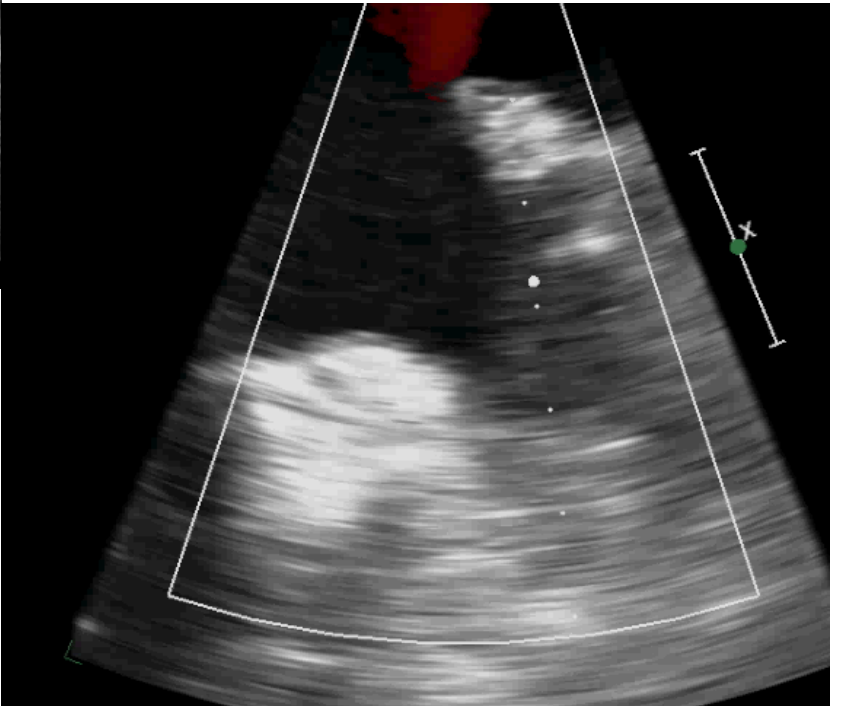
For a one-year follow-up

Palinkas et al. Eur Heart J 2001; 22: 2201.
Antonielli et al J Am Coll Cardiol 2002; 39: 1443

In Sinus rhythm, just after the cardioversion







Take Home messages

Stunning, not taking into account in most our practices, rare are the Acute Pulmonary Edema post cardioversion

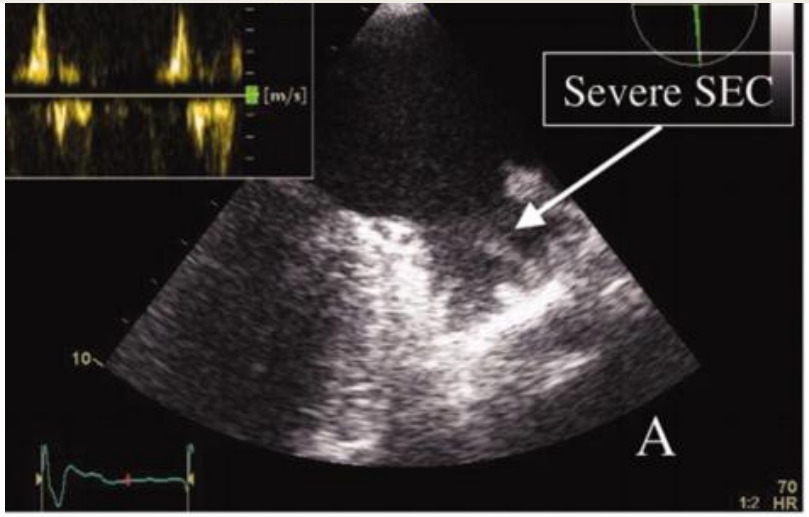
Complexity of the LAA anatomy and necessity, today, to use a 3D TEE +- CT approach (percutaneous closure)

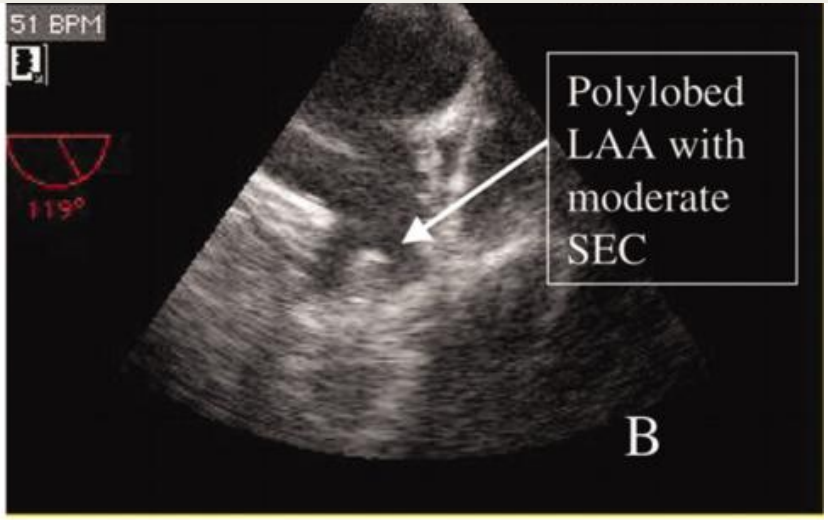
The risk of recurrence of AFIB could be indirectly assess by the LA size but also function assessment,

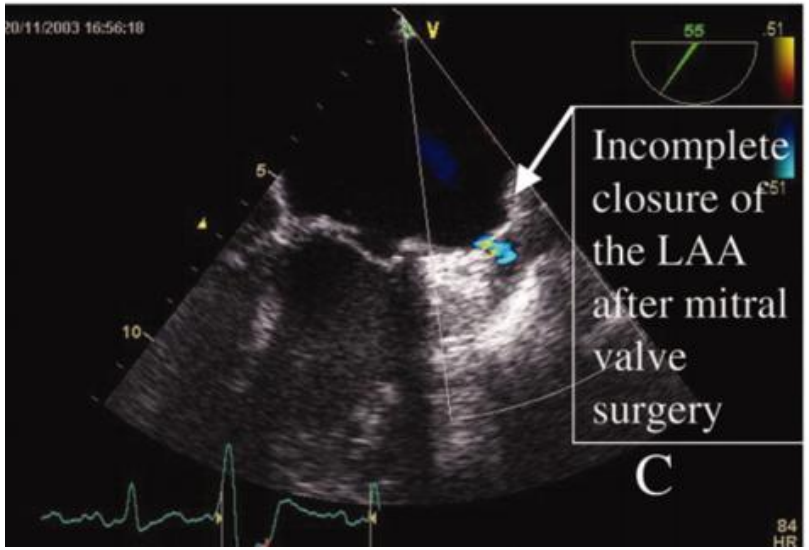
+++Value of LAA function+++

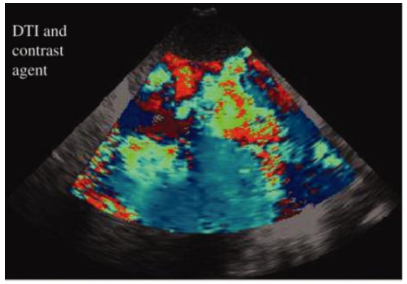
The Left Atrial Appendage, a Small, Blind-Ended Structure*: A Review of Its Echocardiographic Evaluation and Its Clinical Role

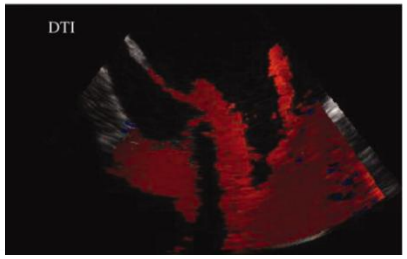
Chest. 2005;128(3):1853-1862. doi:10.1378/chest.128.3.1853







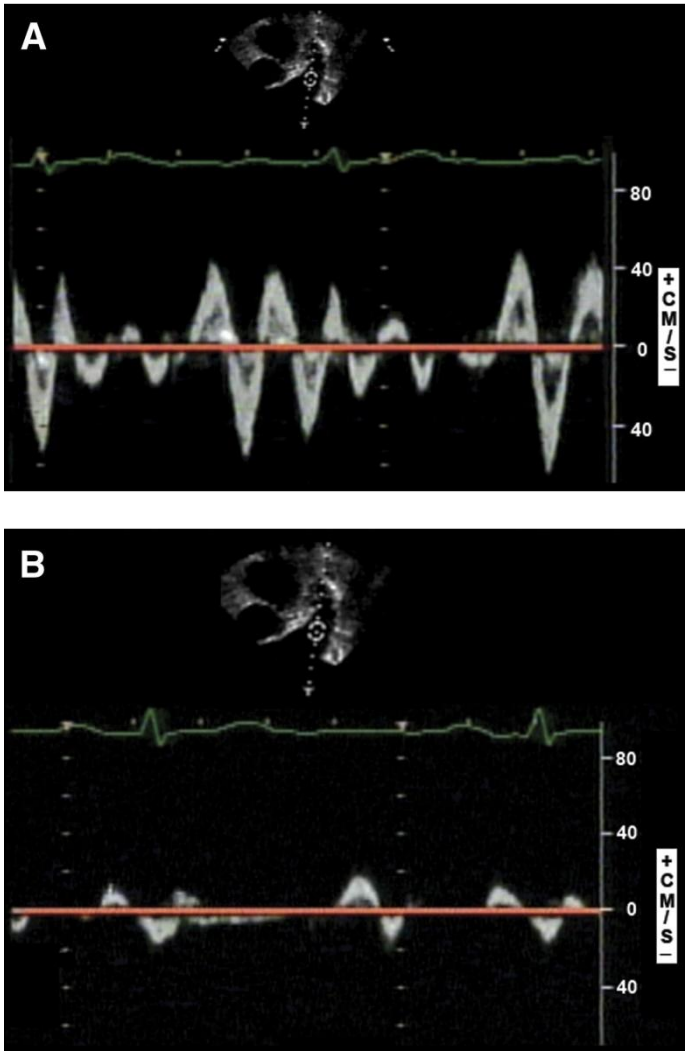


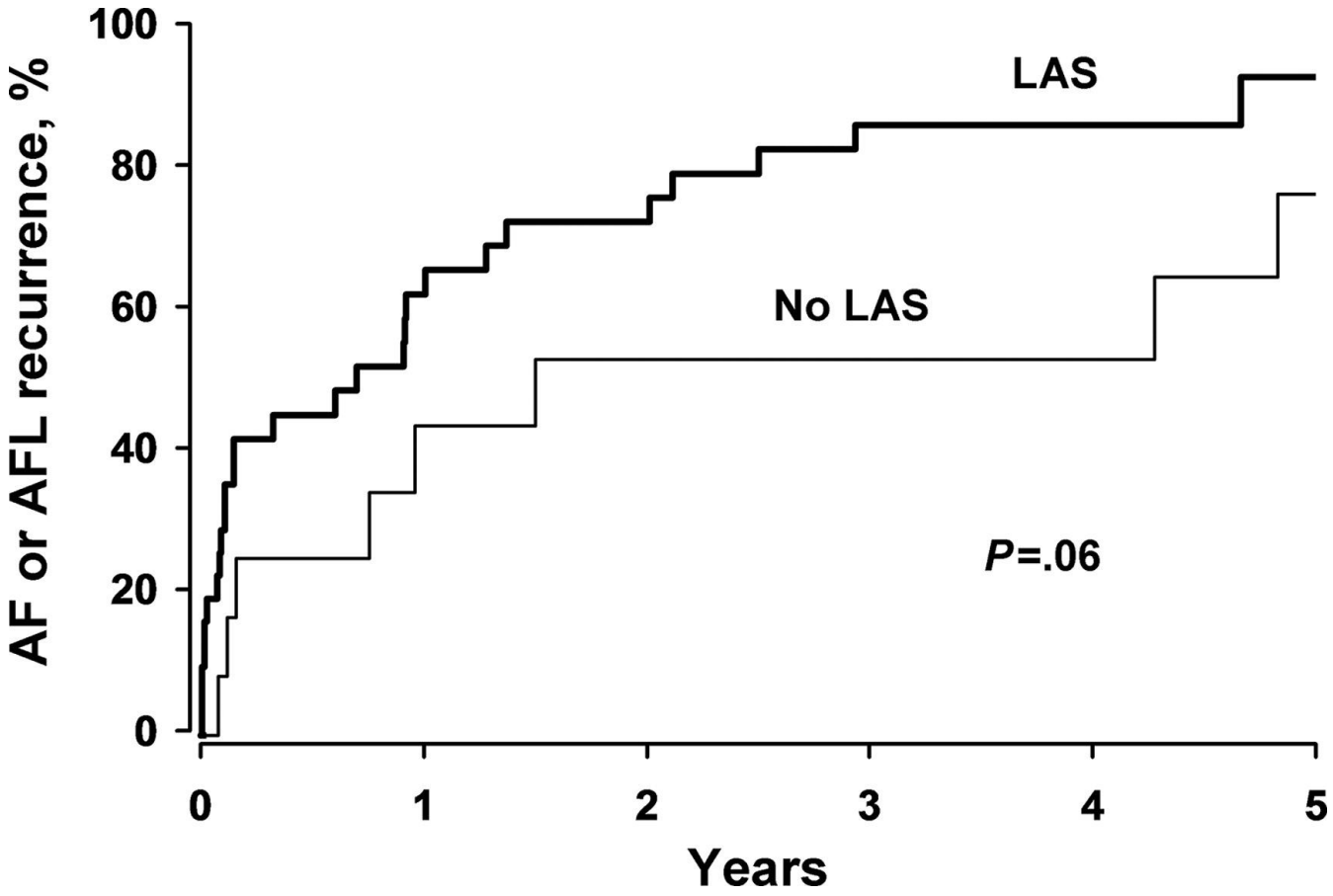


The pseudorestrictive pattern of transmitral Doppler flow pattern after conversion of atrial fibrillation to sinus rhythm: Is atrial or ventricular dysfunction to blame?

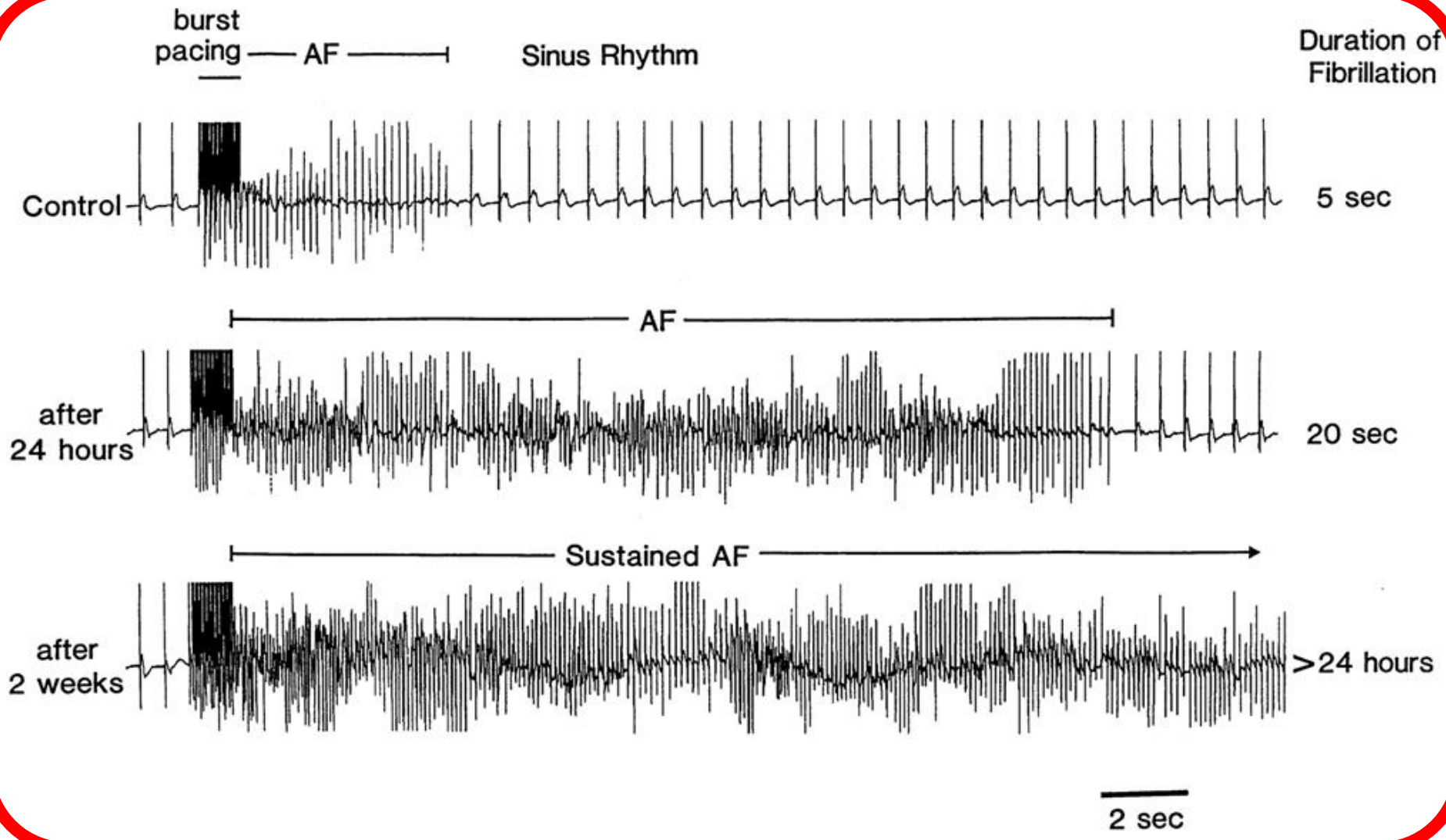
Hirotsugu Yamada, MD, PhD, Erwan Donal, MD, Yong-Jin Kim, MD, Deborah A Agler, RCT, RDCS, Youhua Zhang, MD, Neil L Greenberg, PhD, FACC, Todor N Mazgalev, PhD, FACC, James D Thomas, MD, FACC, Richard A Grimm, DO, FACC

Journal of the American Society of Echocardiography
Volume 17, Issue 8, Pages 813-818 (August 2004)
DOI: 10.1016/j.echo.2004.04.021





AF begets AF

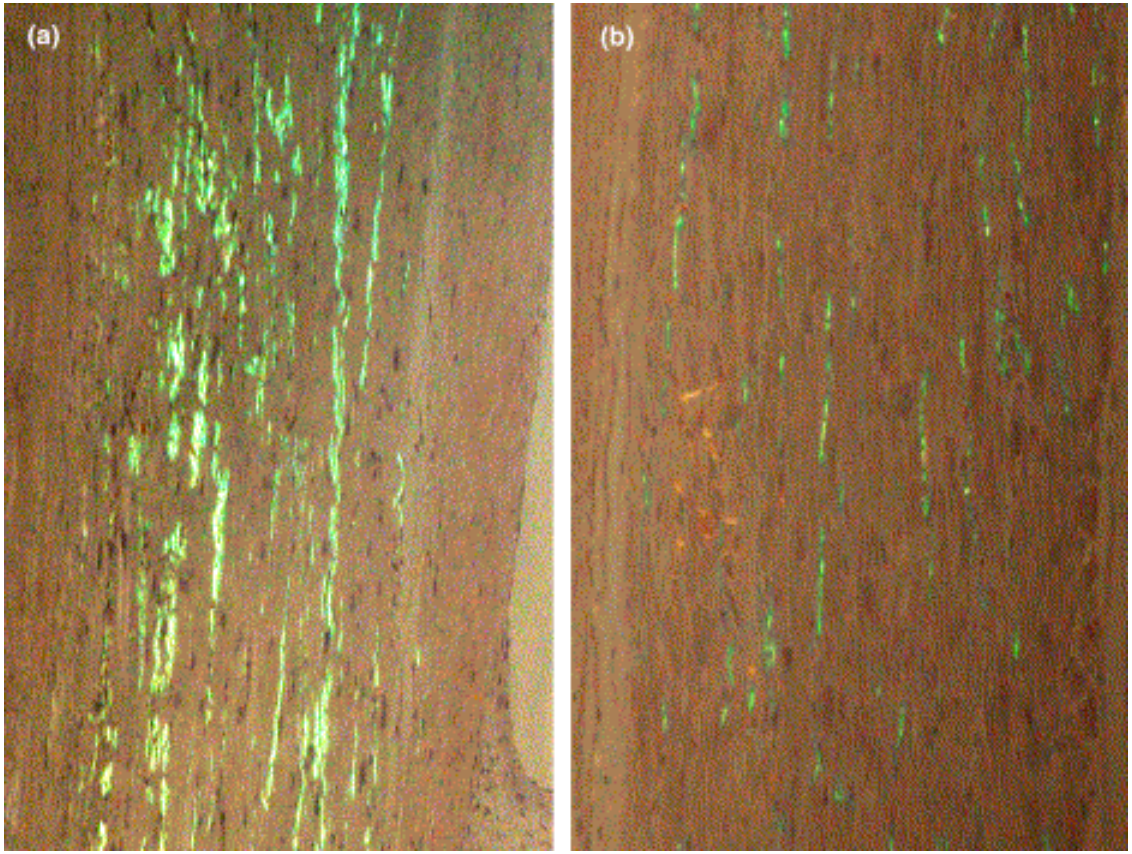


Wijffels MCEF et al. Circulation. 1995;92:1954-1968

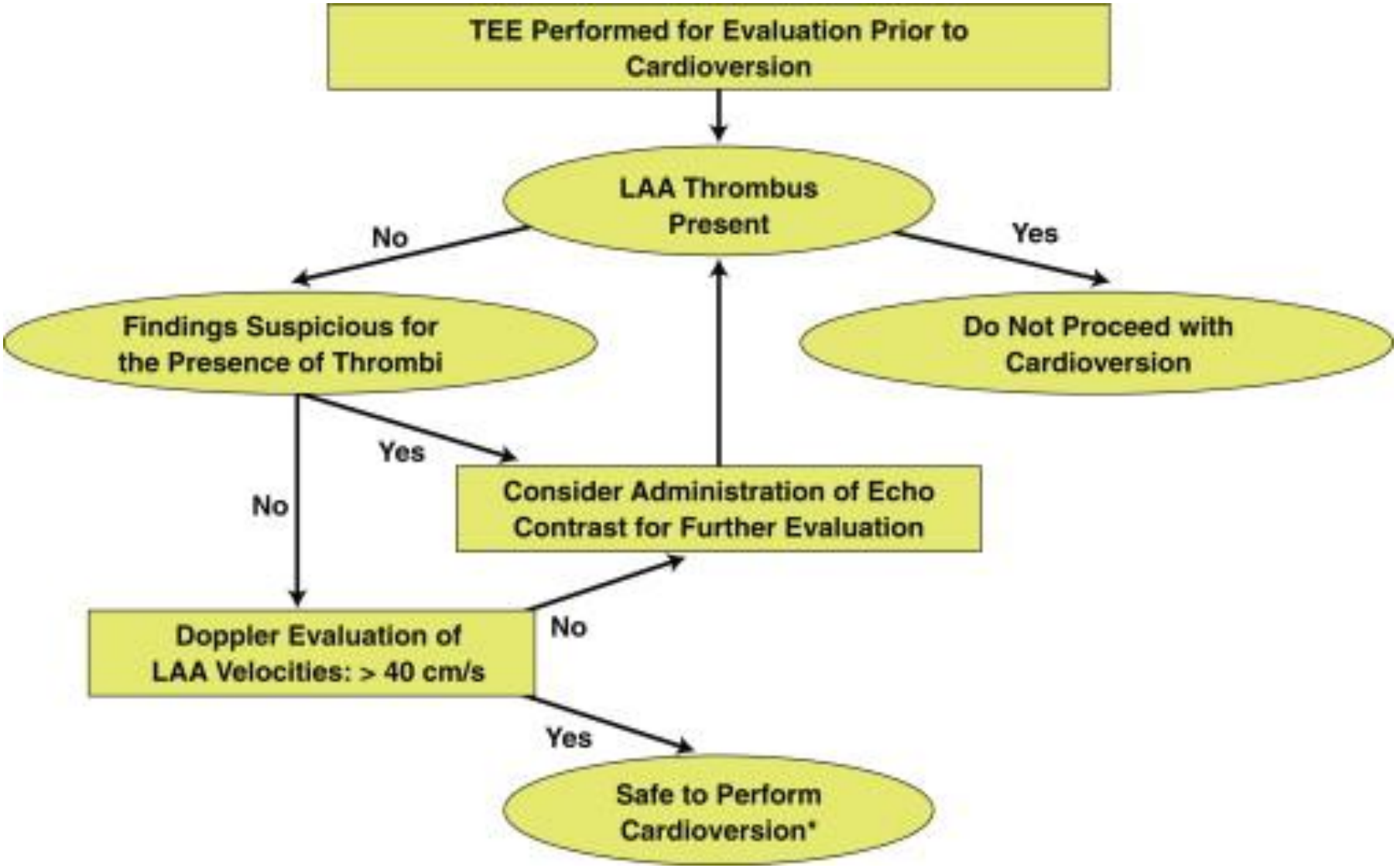
Amyloid Deposition / Atrial remodeling with AF

- Patients with long-standing AF have a very high prevalence of atrial amyloidis, especially in the Left atrium.

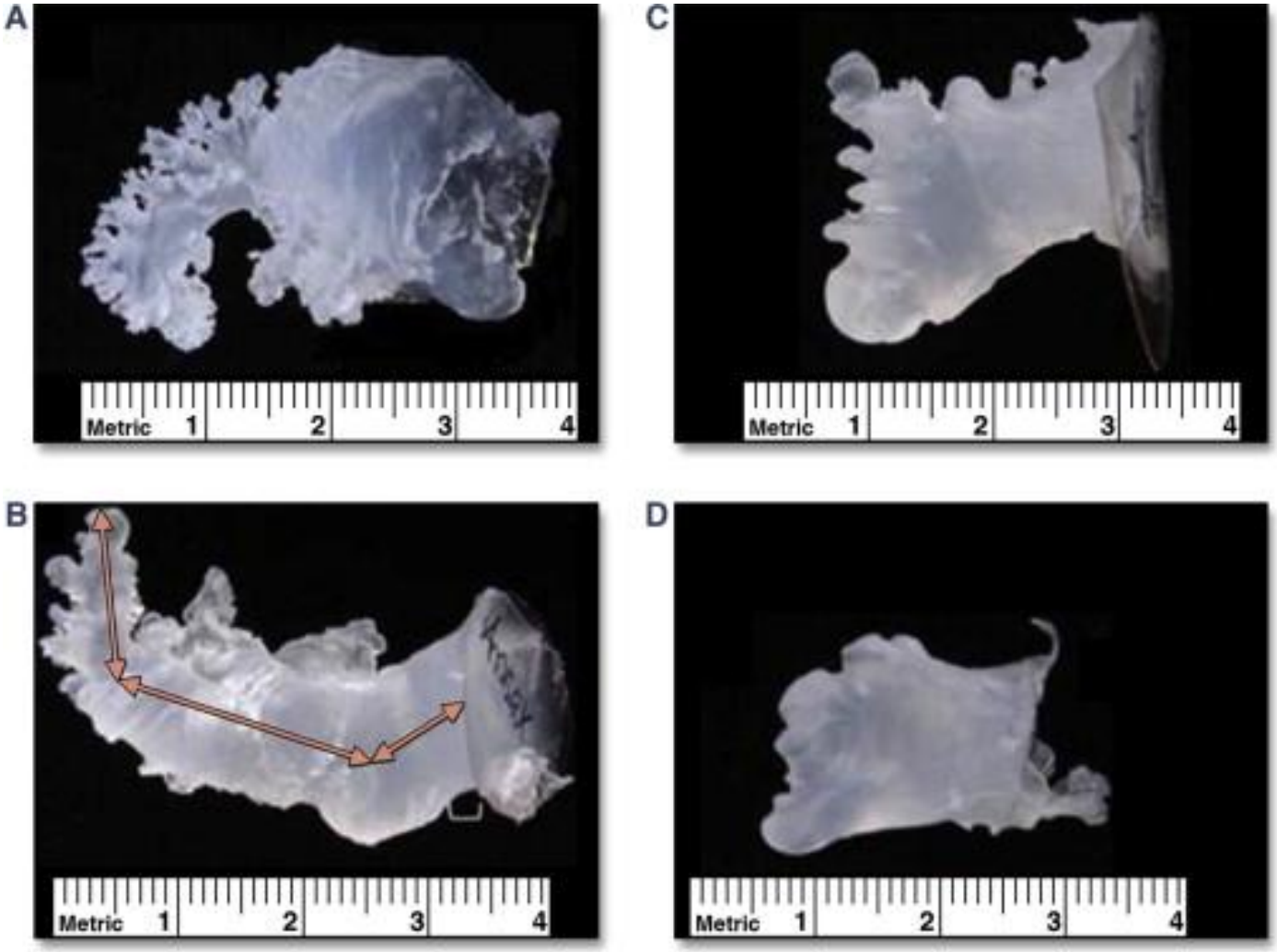
- BNP level is correlated to the risk of developping an AF and BNP level decreases with AF reduction and ARA II prescription.

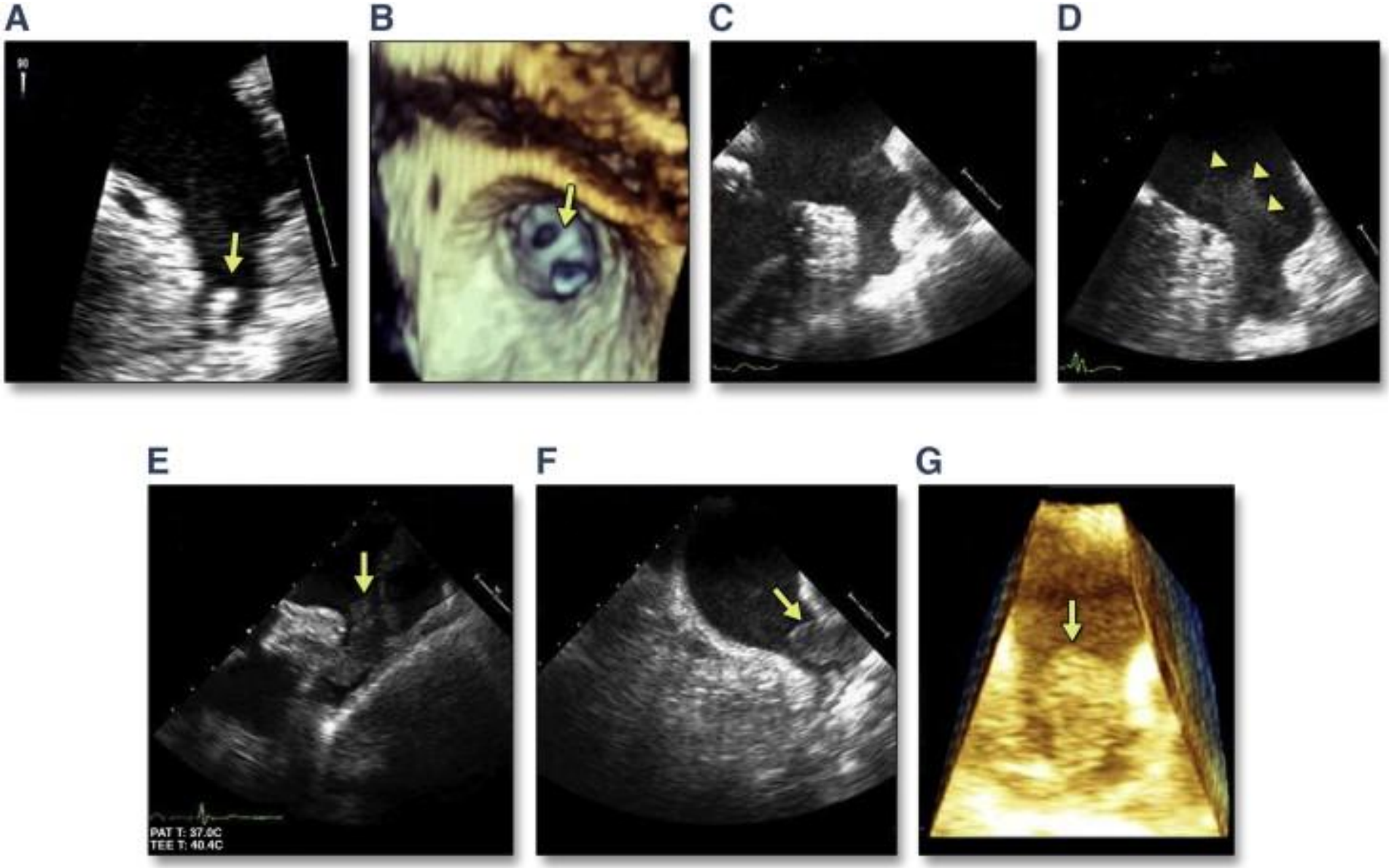


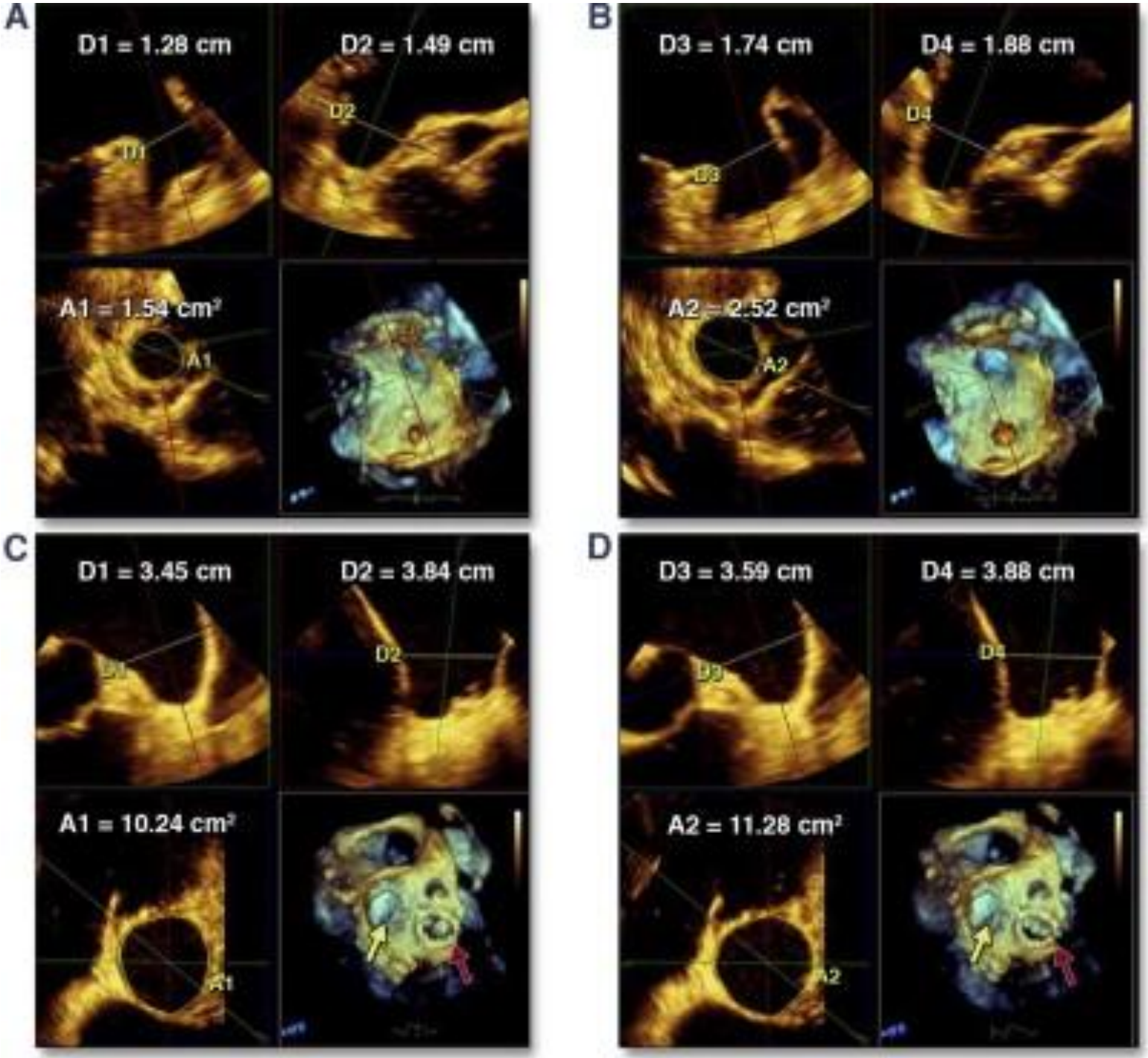
Leone et al. Eur Heart J 2004; 25: 1237.
Wazni et al. Circulation 2004; 110: 124
Wozakowska-Kapton et al. Am J Cardiol 2004; 93: 1555



Beigel R et al. **The Left Atrial Appendage: Anatomy, Function, and Noninvasive Evaluation. Im JACC 2014; 7(12): 1251**


A
Metric 1 2 3 4
C
Metric 1 2 3 4
B
Metric 1 2 3 4
D
Metric 1 2 3 4


A
B
C
D
E
F
G
PAT T: 37.0C
TEE T: 40.4C


A
D1 = 1.28 cm
D2 = 1.49 cm
D1
D2
A1 = 1.54 cm²
A1
B
D3 = 1.74 cm
D4 = 1.88 cm
D3
D4
A2 = 2.52 cm²
A2
C
D1 = 3.45 cm
D2 = 3.84 cm
D1
D2
A1 = 10.24 cm²
A1
D
D3 = 3.59 cm
D4 = 3.88 cm
D3
D4
A2 = 11.28 cm²
A2

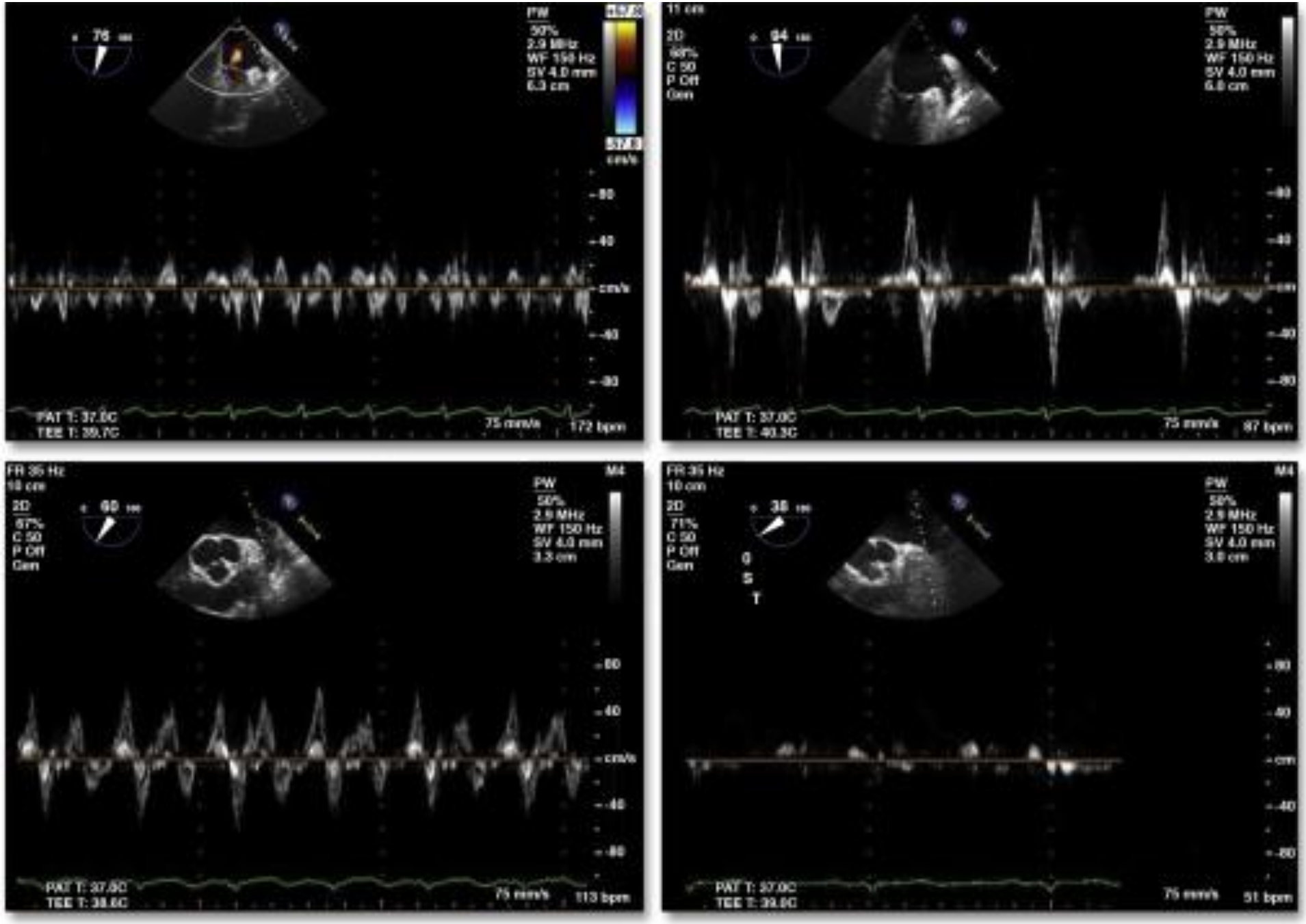

PW
50%
2.9 MHz
WF 150 Hz
SV 4.0 mm
6.3 cm
cm/s
PAT T: 37.0C
TEE T: 39.7C
75 mm/s
172 bpm
2D
C 50
P Off
Gen
PW
50%
2.9 MHz
WF 150 Hz
SV 4.0 mm
6.0 cm
PAT T: 37.0C
TEE T: 40.3C
75 mm/s
87 bpm
FR 35 Hz
10 cm
2D
67%
C 50
P Off
Gen
M4
PW
50%
2.9 MHz
WF 150 Hz
SV 4.0 mm
3.3 cm
PAT T: 37.0C
TEE T: 38.6C
75 mm/s
113 bpm
FR 35 Hz
10 cm
2D
71%
C 50
P Off
Gen
M4
PW
50%
2.9 MHz
WF 150 Hz
SV 4.0 mm
3.0 cm
PAT T: 37.0C
TEE T: 39.6C
75 mm/s
51 bpm

TABLE 2 Transesophageal Echocardiographic Evaluation of the LAA

	Pathophysiology	Echocardiographic Appearance	Treatment
SEC	Low blood flow velocities. Composed of activated platelets and leukocytes or aggregated red blood cells.	Swirling echodensity within the atrium.	Anticoagulation does not reduce SEC but reduces the development of LAA thrombus. Cardioversion is acceptable. SEC can initially increase, but eventually decreases after cardioversion.
Sludge	Low blood flow velocities.	Viscous, gelatinous morphology, not well formed. Represents an intermediate stage between SEC and formed thrombus.	Anticoagulation. Cardioversion in the setting of sludge is controversial and associated with a higher risk of thrombus being present.
Thrombus	Low blood flow velocities.	Organized formed thrombus.	Anticoagulation. Cardioversion contraindicated with this finding.
Pectinate muscle	Part of the normal LAA morphology.		No treatments, normal finding.

LAA = left atrial appendage; SEC = spontaneous echocardiographic contrast.

TABLE 5 Comparison Between MDCT and TEE for Evaluation of the LAA Including Assessment of Patients for Percutaneous LAA Closure

	MDCT	TEE
LAA thrombus detection	+	2D/3D ++
Assessment of LAA function	+	+++
LAA orifice size	++	2D + 3D ++
LAA morphology	++	2D + 3D ++
Evaluation of intracardiac structures	+++	2D + 3D +++
Evaluation of extracardiac structures	+++	-
Intraprocedural guidance	-	2D ++ 3D +++

TABLE 4 Comparison of the Different Imaging Modalities for Assessment of the LAA

	TEE	MDCT	CMR
Sensitivity/specificity for LAA thrombi detection	92%–100%/ 98%–99%	96%/92%	67%/44%
Spatial resolution	0.2–0.5 mm	0.4 mm	1–2 mm
Temporal resolution	20–33 ms	70–105 ms	30–50 ms
3D volume rendering	Yes (with 3D)	Yes	Yes
Contrast required	No*	Yes	No*
Ionizing radiation	No	Yes	No
Special considerations	Widely available, provides real-time assessment Semi-invasive	Noninvasive, dynamic assessment of LA function Cannot be performed real-time during procedures Limited availability	Noninvasive, cannot be performed real-time during procedures Limited availability Cannot be performed in patients with pacemakers

Indices of Atriale emptying:
(not used in clinical routine)

1. LA total emptying volume index = LAVImax x LAVImin,
2. LA passive emptying volume index = LAVImax x LAVIpre-a,
3. LA active emptying volume index = LAVIpre-a x LAVImin.

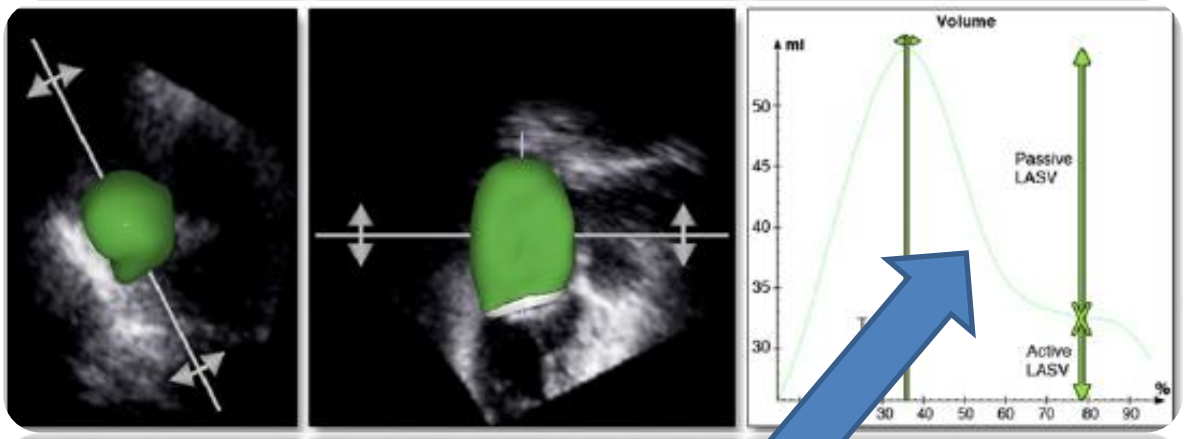
Stefanadis et al. Eur H J 2001 & Manning JACC 1993

<u>Reservoir Function</u>: 2 indices:

1. expansion index = [(LAVImax LAVImin)/LAVImin] x 100

2. diastolic emptying index = [(LAVImax LAVImin)/LAVImax] x 100.

Stefanadis et al. Eur H J 2001 & Manning JACC 1993



Conduit Function : 2 indices:

1. passive emptying % of total emptying =

[(LAVImax x LAVIpre-a)/(LAVImax x LAVImin)] x100

2. passive emptying index =

(LAVImax x LAVIpre-a)/LAVImax x100

Stefanadis et al. Eur H J 2001 & Manning JACC 1993

Booster pump function :

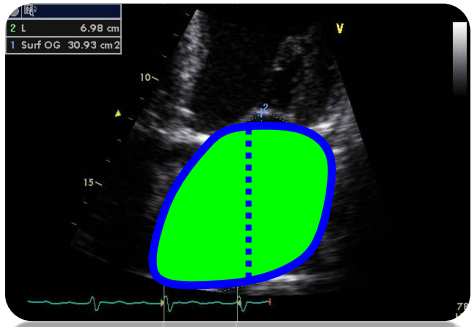
2 indices:

1. active emptying percentage of total emptying = [(LAVIpre-a LAVImin)/(LAVImax LAVImin)] x100

2. active emptying index = (LAVIpre-a LAVImin)/LAVIpre-a x 100.

Stefanadis et al. Eur H J 2001 & Manning JACC 1993

Plusieurs indices ont été proposés dans la littérature mais sont peu utiles à notre pratique…

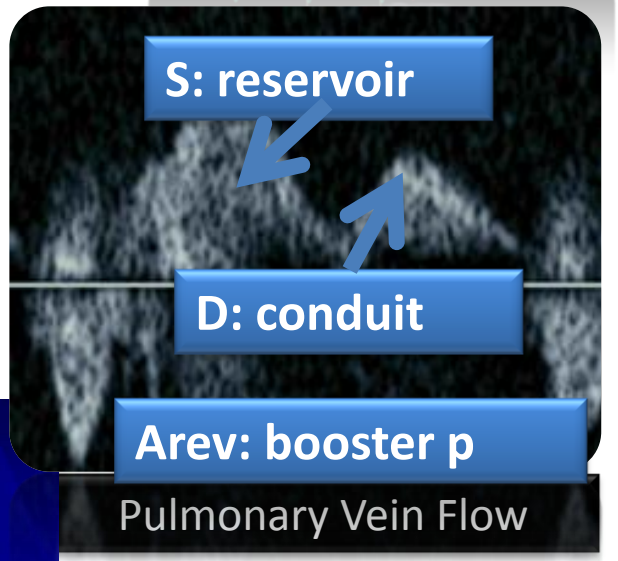


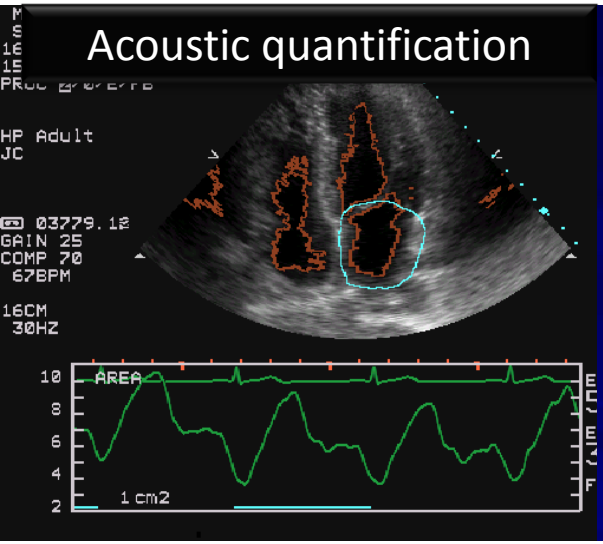
- Left atrial ejection force:

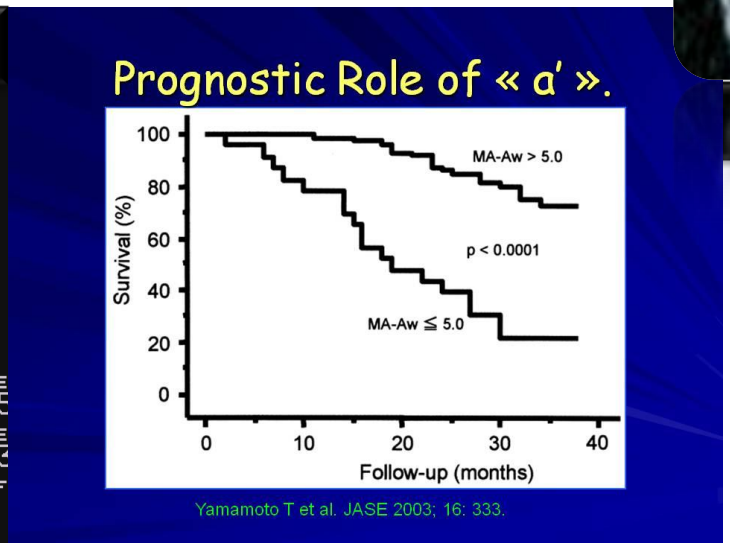
1/2xStr.Vol.xρxAvel²

- Left atrial kinetic energy:

Mitral VTIxOG EF/OG max surf.

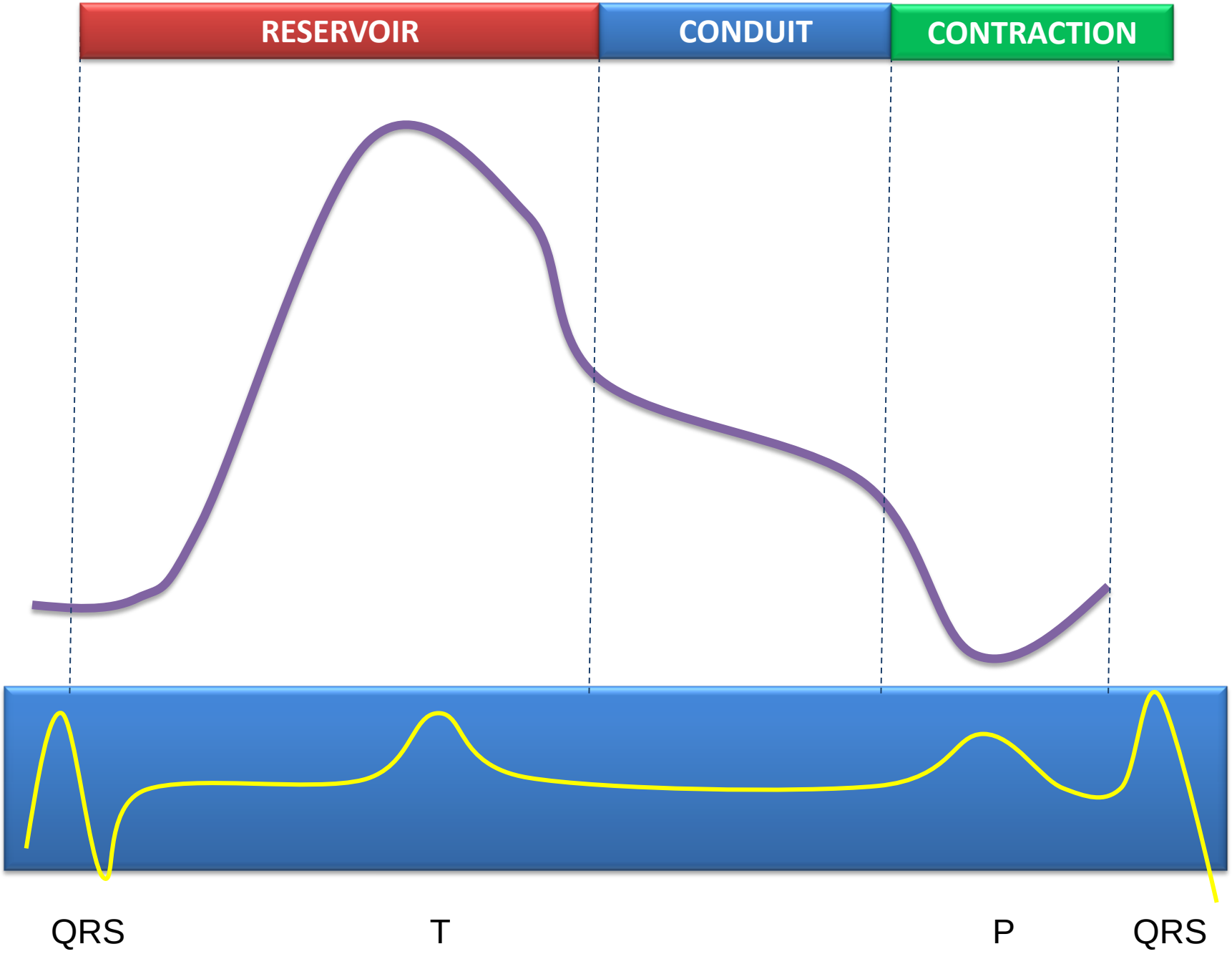


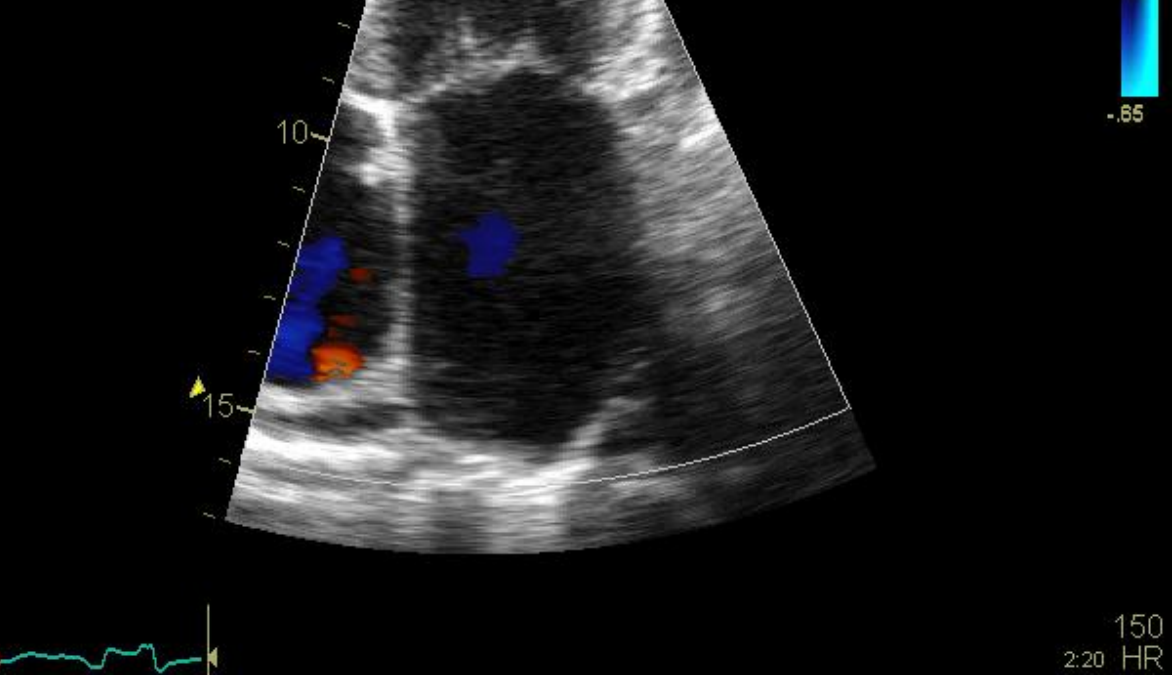




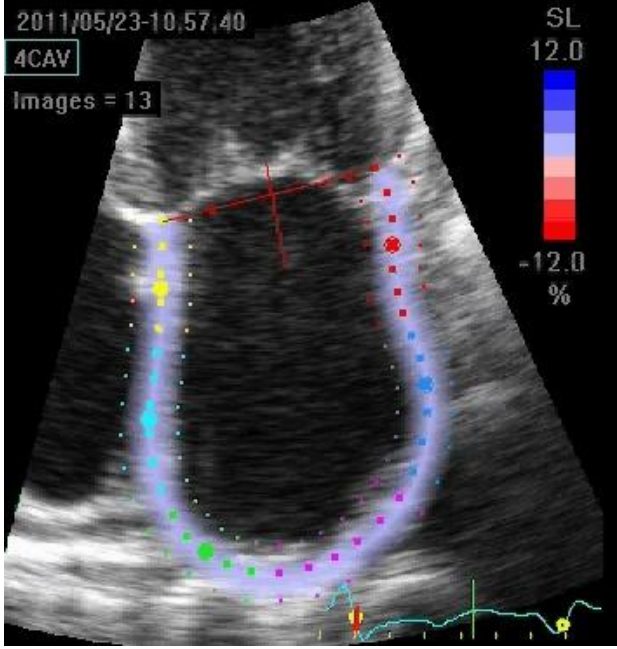
Stefanadis et al. Eur H J 2001 & Manning JACC 1993

Deformation du Myocarde Atrial

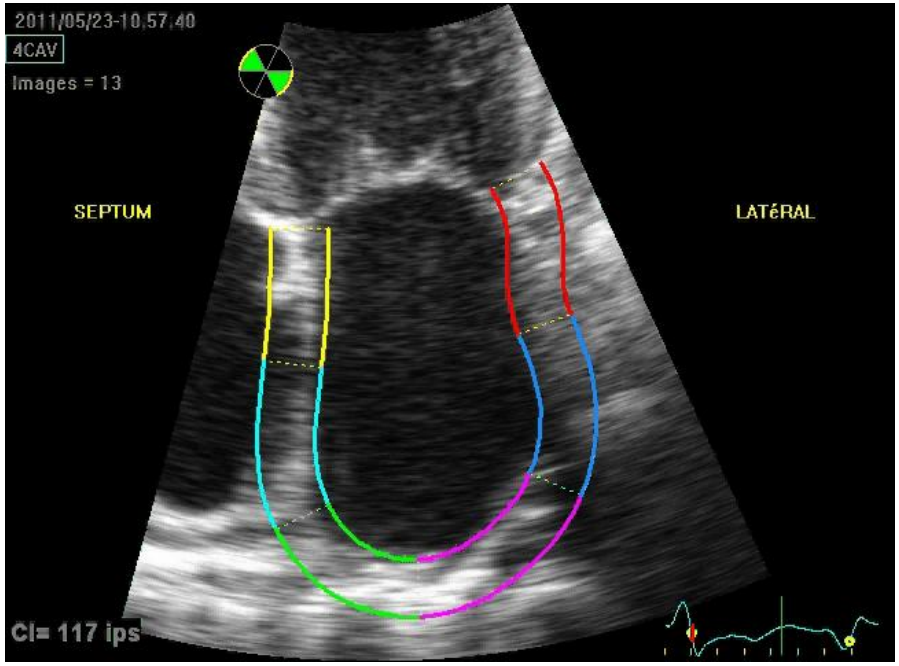




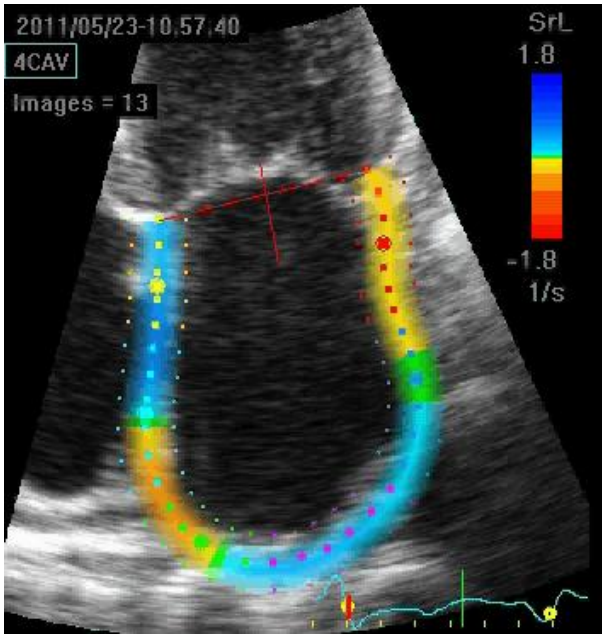
Strain (%)

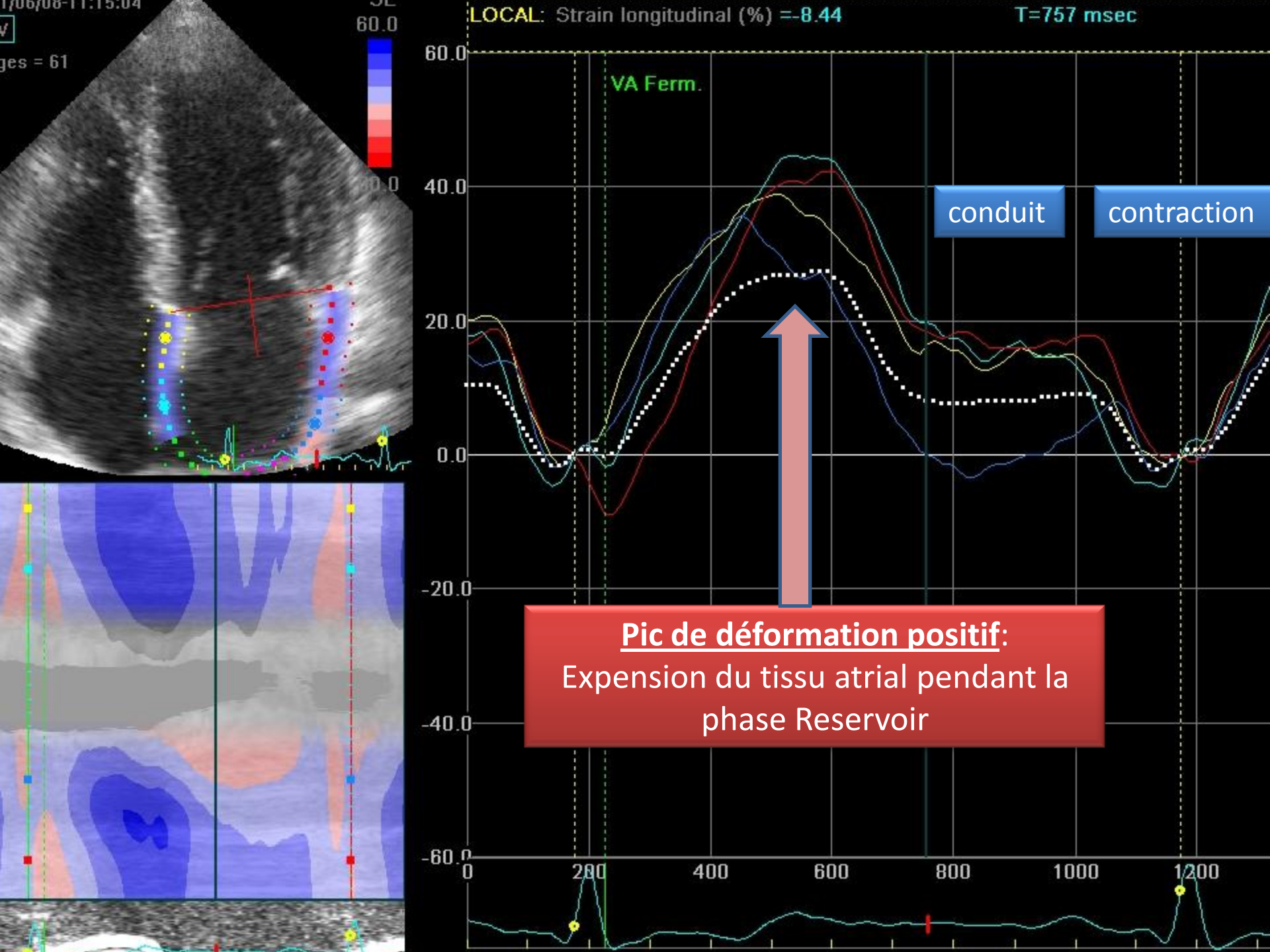


Semi-automatic borders detection

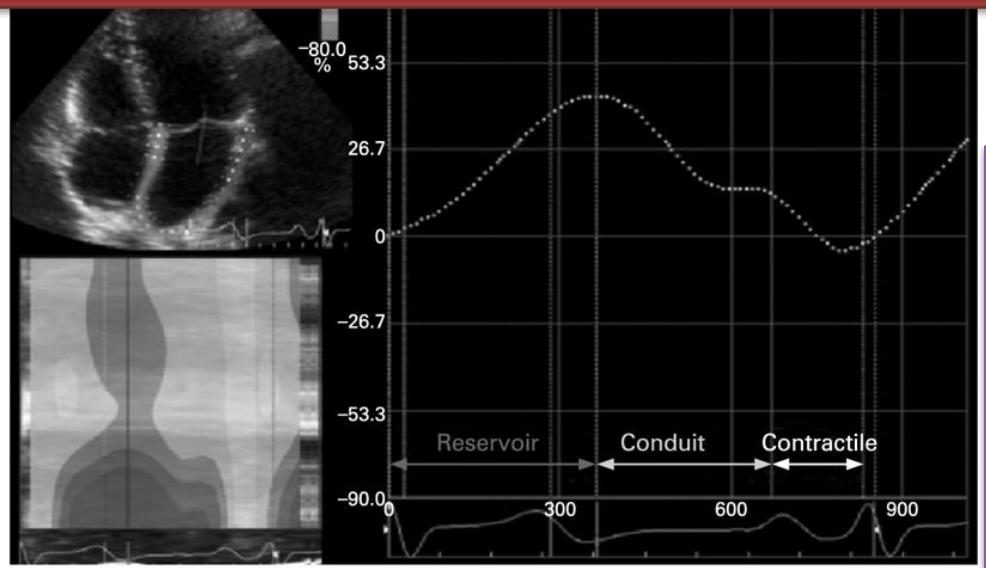


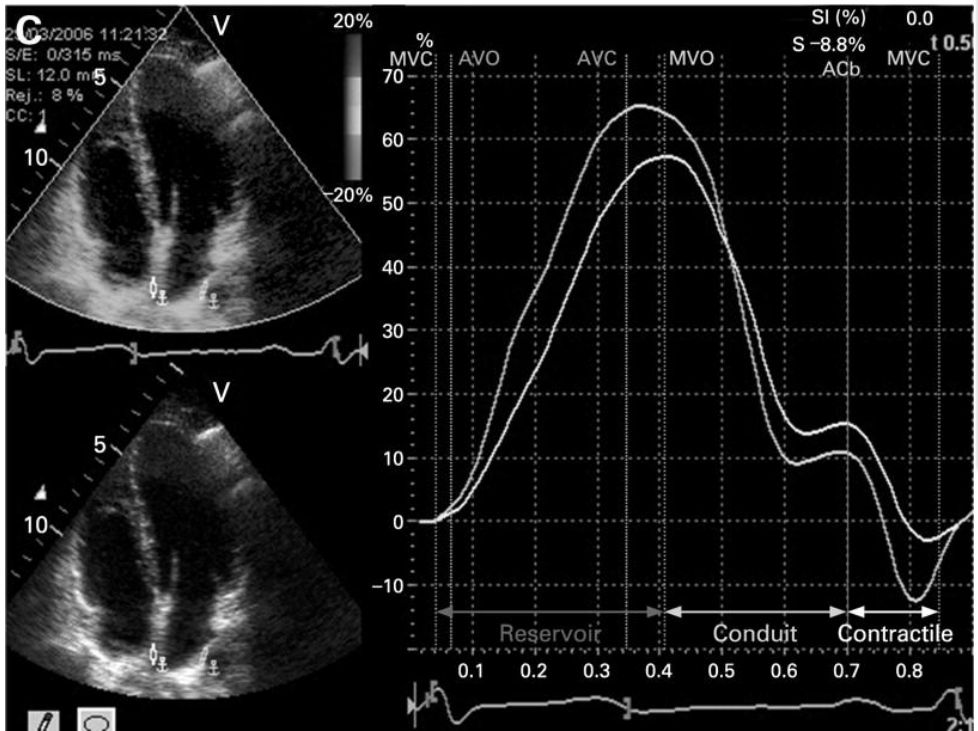
Strain Rate (s-1)




LOCAL: Strain longitudinal (%) =-8.44
T=757 msec
VA Ferm.
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
0
200
400
600
800
1000
1200
conduit
contraction
Pic de déformation positif:
Expension du tissu atrial pendant la phase Reservoir

Le strain atrial. C'est fiable?





L'étude des déformations (strain) avec le speckle tracking est **robuste**

Variabilité Intra-observateur = 8%

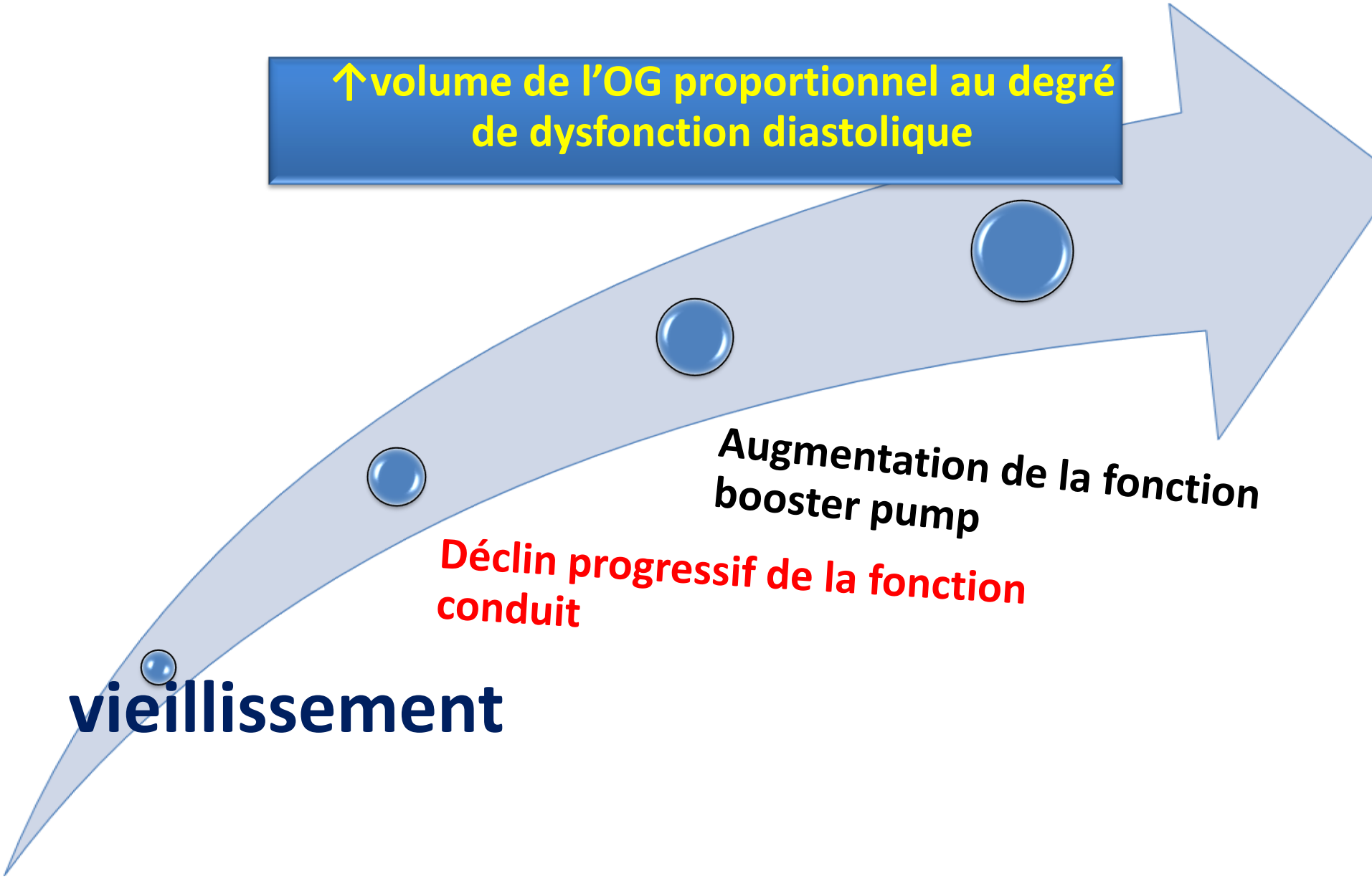
Inter-observateur 9.5%

Temps nécessaire pour étude de la fonction atriale: 3.8minutes

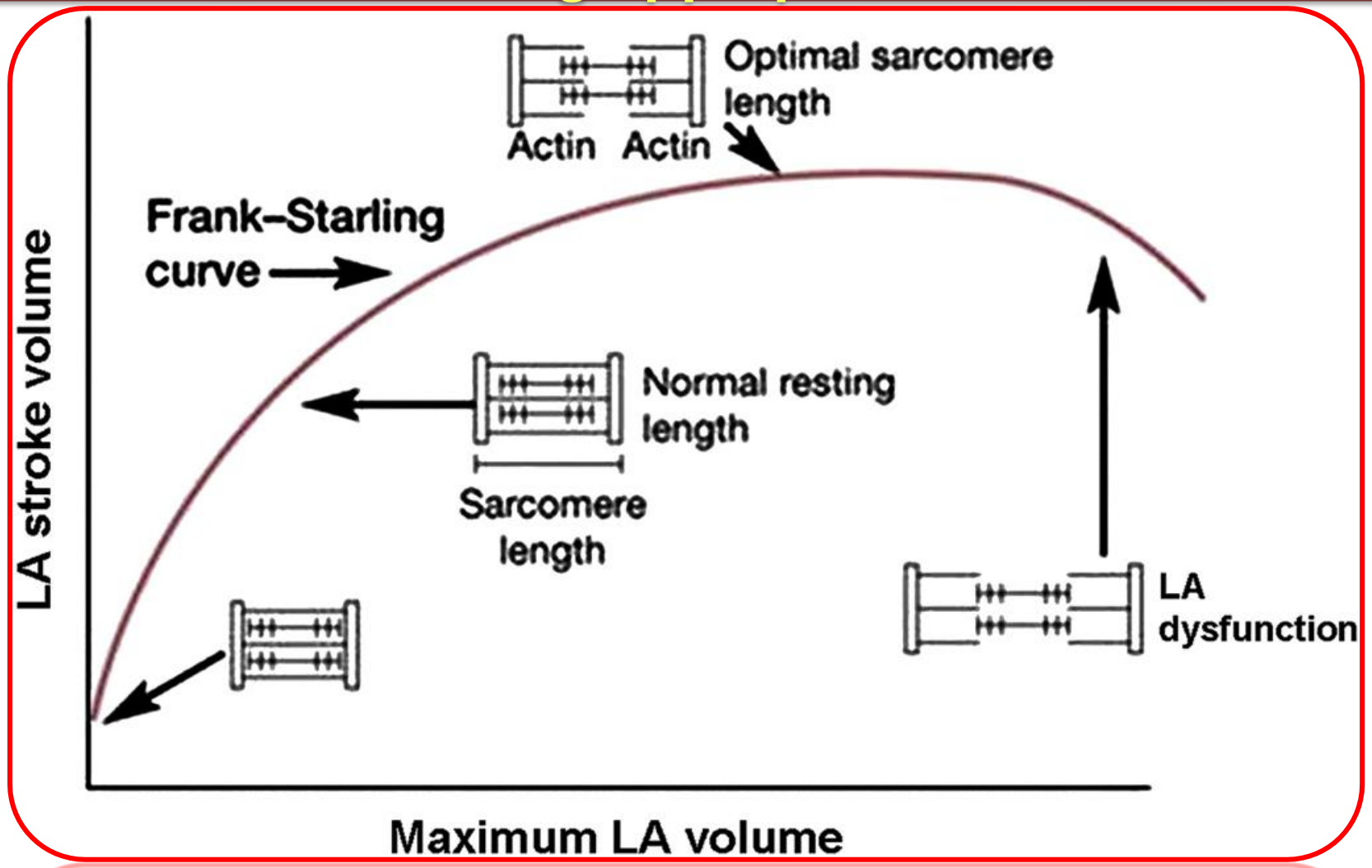
Paraskevaidis I A et al.
Heart 2009;95:483-489

CHANGEMENT LIE à L'ÂGE DU STRAIN SYSTOLIQUE (reservoir) ET DU **STRAIN RATE DIASTOLIQUE** ET CE SURVIENT JUSQU'à *UNE DECADE AVANT* LES ALTERATONS DES PARAMETRES DE **VOLUME**

Boyd et al. Heart 2011; 97: 1513


↑volume de l'OG proportionnel au degré de dysfonction diastolique
Augmentation de la fonction booster pump
Déclin progressif de la fonction conduit
vieillissement

Frank–Starling appliqué à l'oreillette

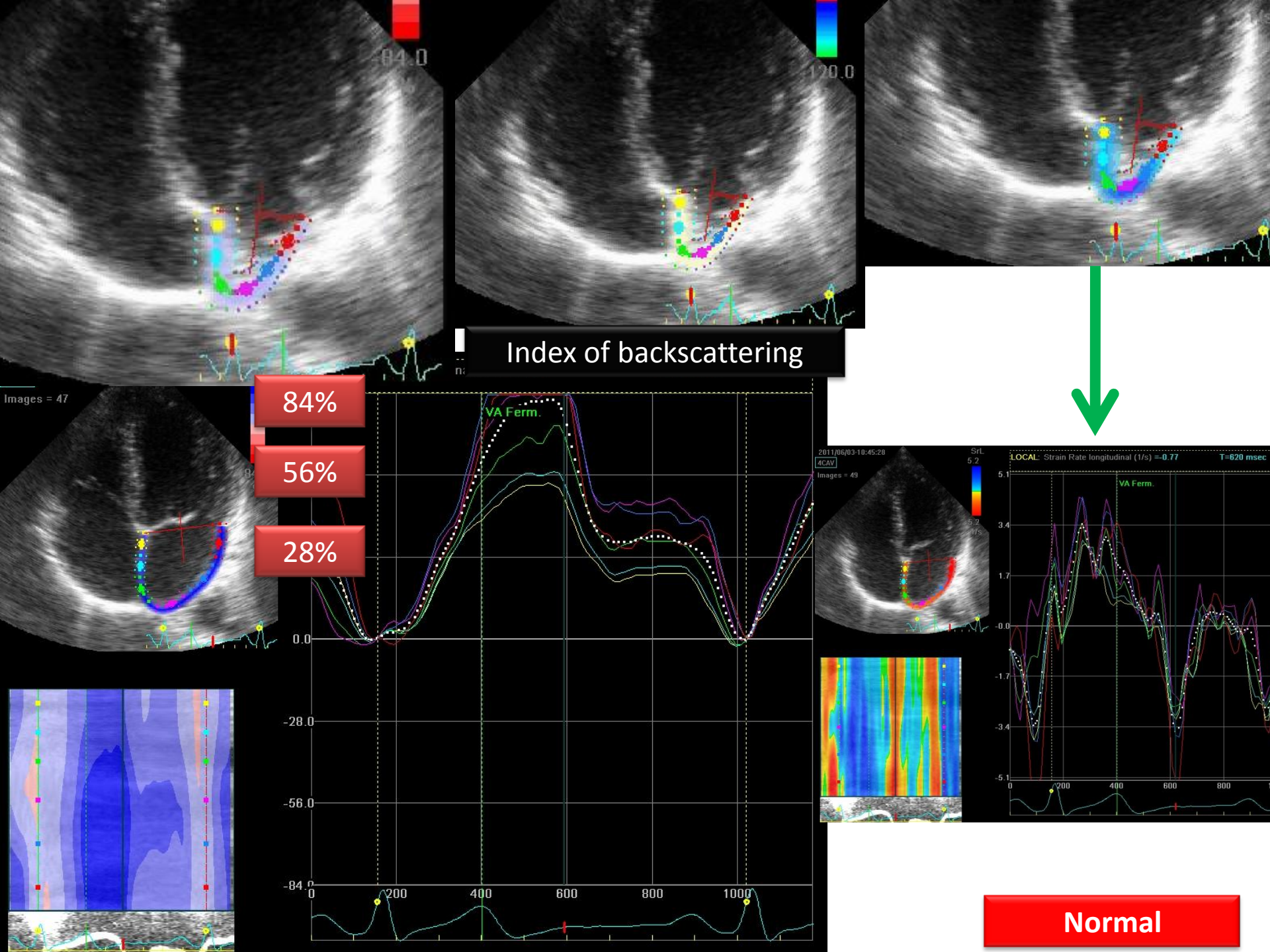


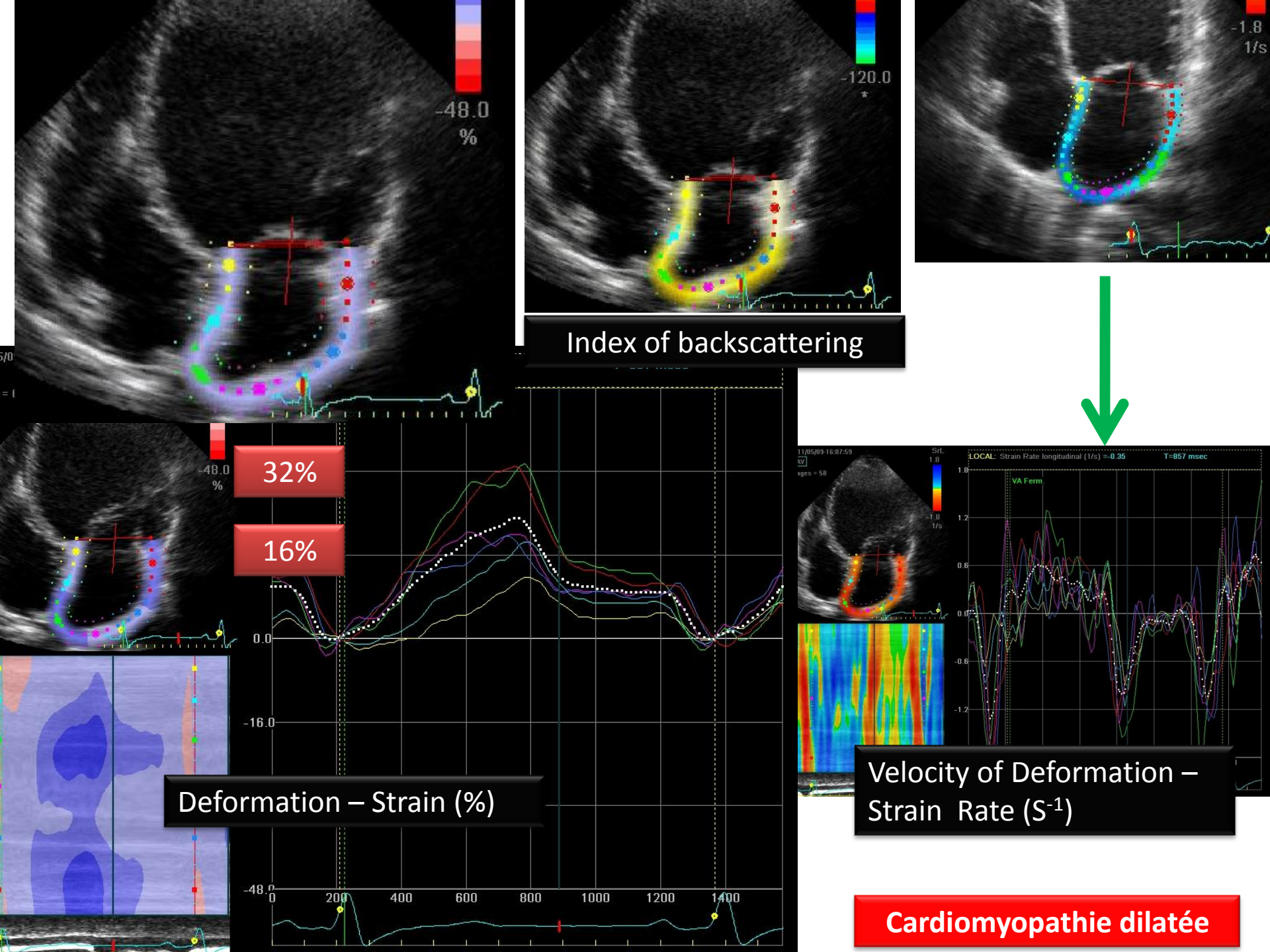
Roşca M et al. Heart 2011;97:1982

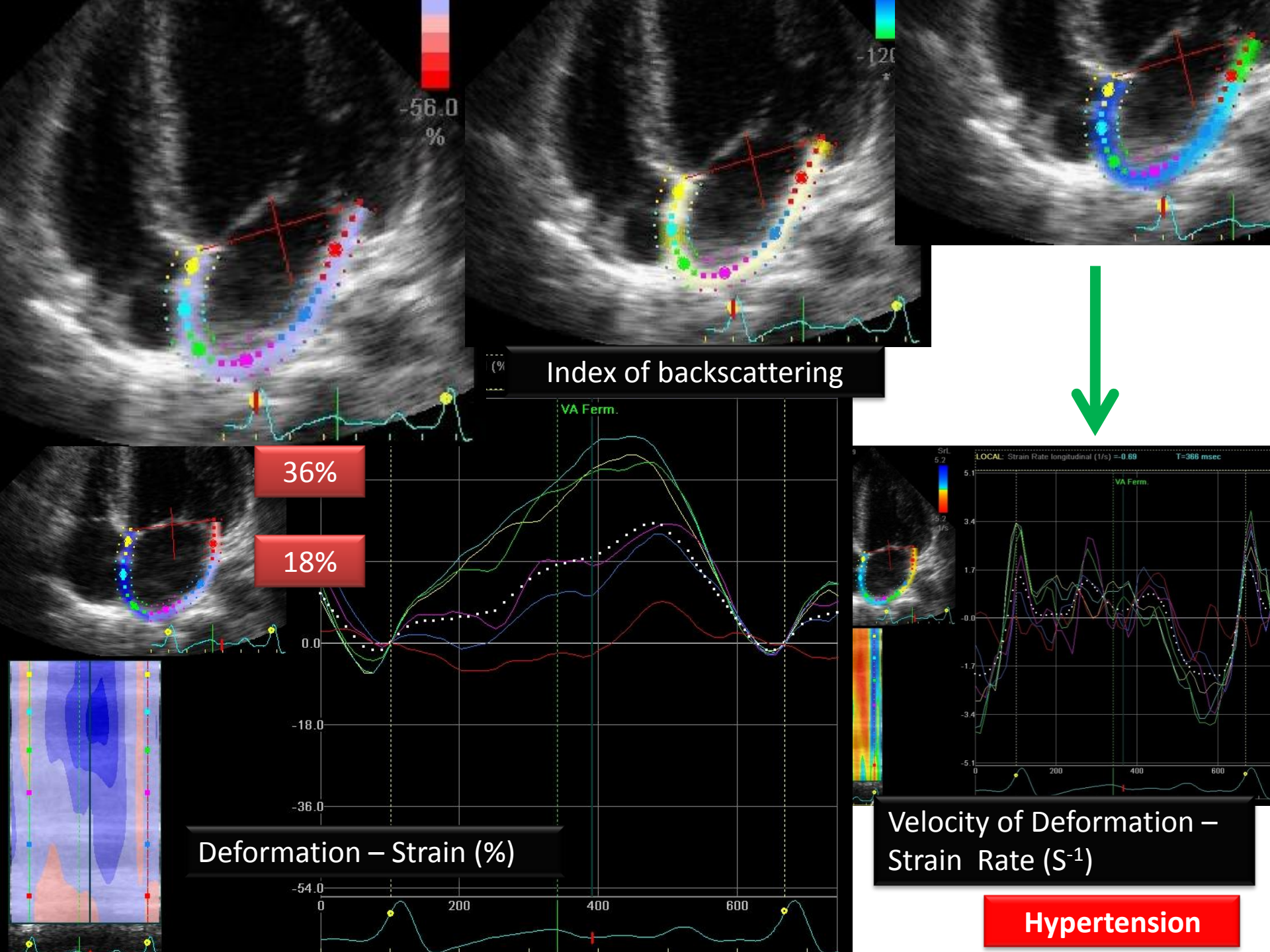
Deformations OG s'altèrent chez les HTA et diabétiques même sans dilatation.

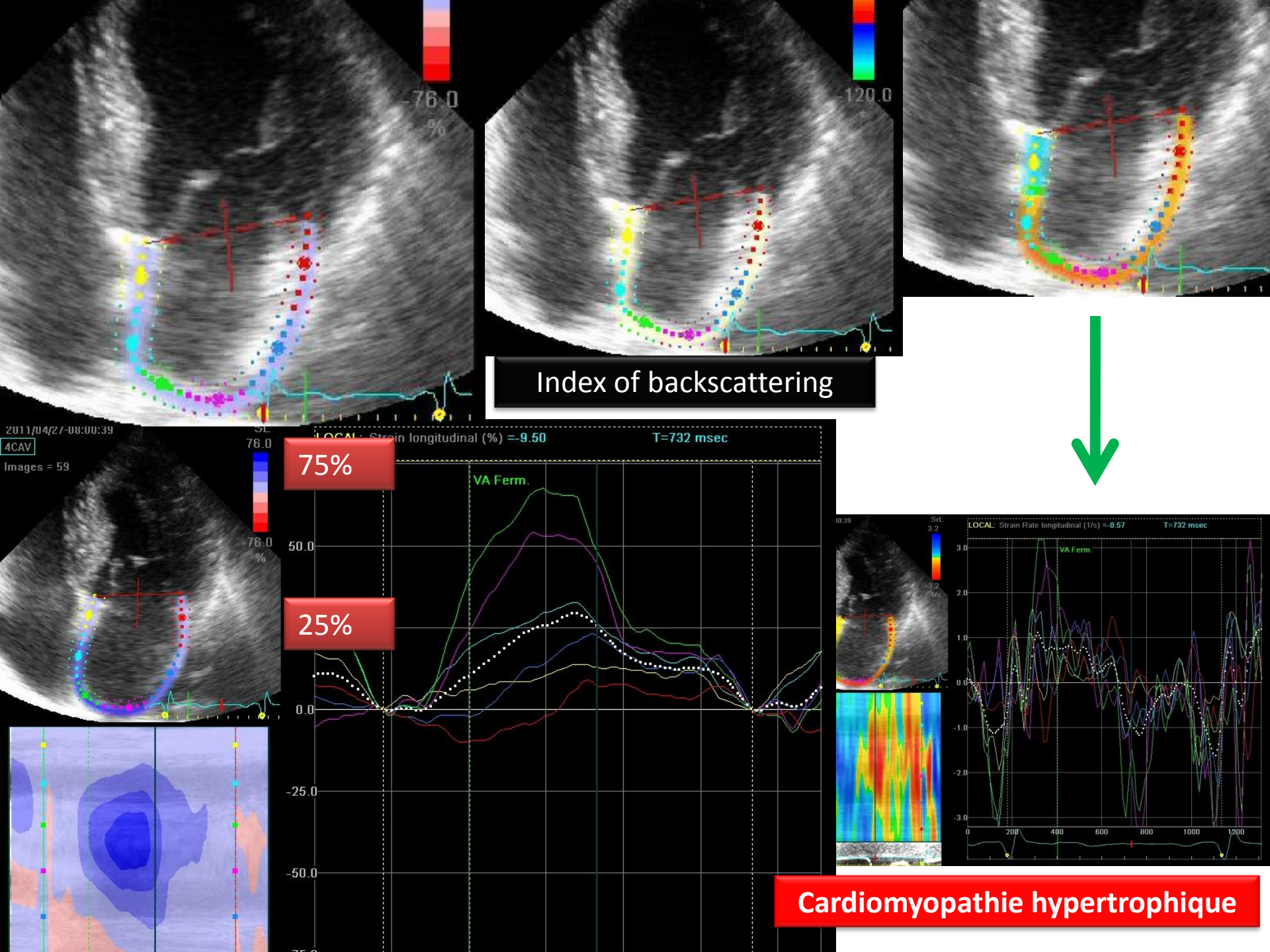
- LA conduit ↘ avec l'âge
- LA reservoir presque constante
- LA booster pump function augmente un peu

Mondillo et al. JASE 2011; 24: 898-908
Boyd et al . Heart 2011; 97: 1513


Index of backscattering
84%
56%
28%
VA Ferm.
0.0
-28.0
-56.0
-84.0
0
200
400
600
800
1000
LOCAL: Strain Rate longitudinal (1/s) =-0.77
T=620 msec
Normal


-48.0
%
-120.0
-1.8
1/s
Index of backscattering
32%
16%
0.0
-16.0
-48.0
0
200
400
600
800
1000
1200
1400
Deformation – Strain (%)
LOCAL: Strain Rate longitudinal (1/s) =-0.35
T=857 msec
VA Ferm
Velocity of Deformation – Strain Rate (S-1)
Cardiomyopathie dilatée


-56.0
%
Index of backscattering
36%
18%
VA Ferm.
0.0
-18.0
-36.0
-54.0
0
200
400
600
Deformation – Strain (%)
LOCAL: Strain Rate longitudinal (1/s) =-0.69
T=366 msec
VA Ferm.
5.1
3.4
1.7
-0.0
-1.7
-3.4
-5.1
Velocity of Deformation – Strain Rate (S-1)
Hypertension

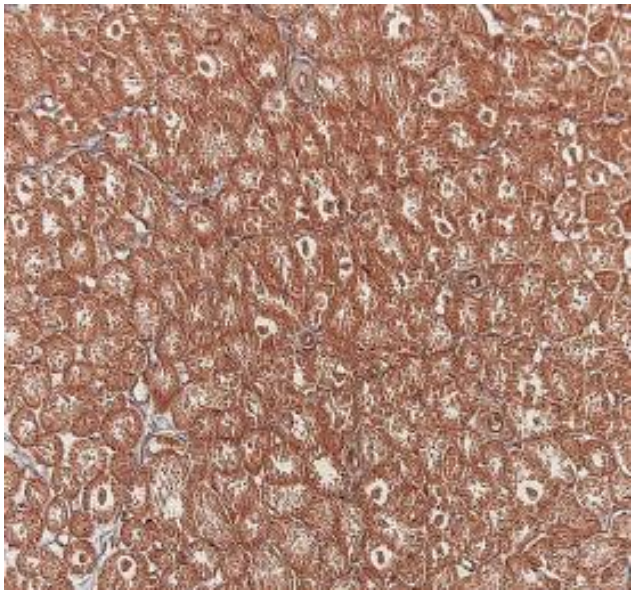

-76.0
%
-120.0
Index of backscattering
2011/04/27-08:00:39
4CAV
Images = 59
76.0
-76.0
%
LOCAL: Strain longitudinal (%) =-9.50
T=732 msec
75%
25%
VA Ferm.
50.0
0.0
-25.0
-50.0
LOCAL: Strain Rate longitudinal (1/s) =-0.57
T=732 msec
VA Ferm.
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
0
200
400
600
800
1000
1200
Cardiomyopathie hypertrophique

Remodelage atrial

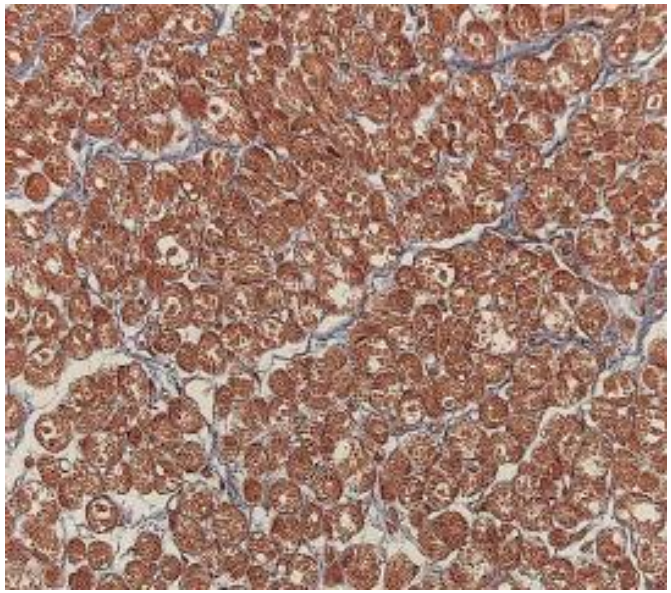
- **Altération de la fonction puis dilatation**

- **Fibrose interstitielle**

Kumagai. J Am Coll Cardiol. 2003; 41: 2197-204



Contrôle



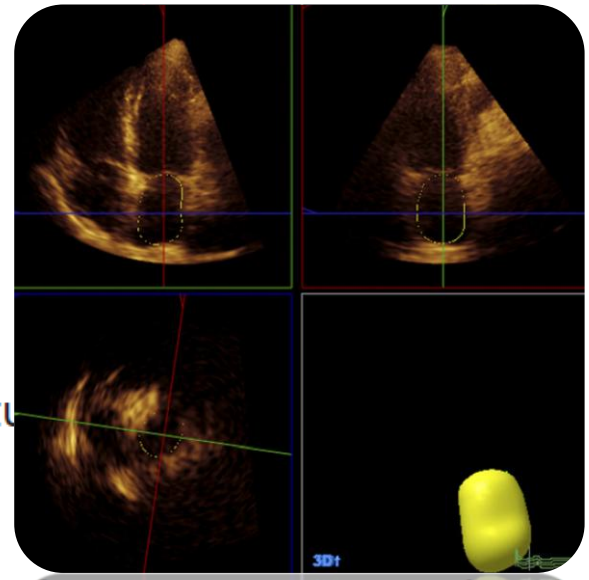
FA

- **Remodelage de la matrice extra-cellulaire**
- **“TIMP-2 Down-regulation & MMP-2 up-regulation”**

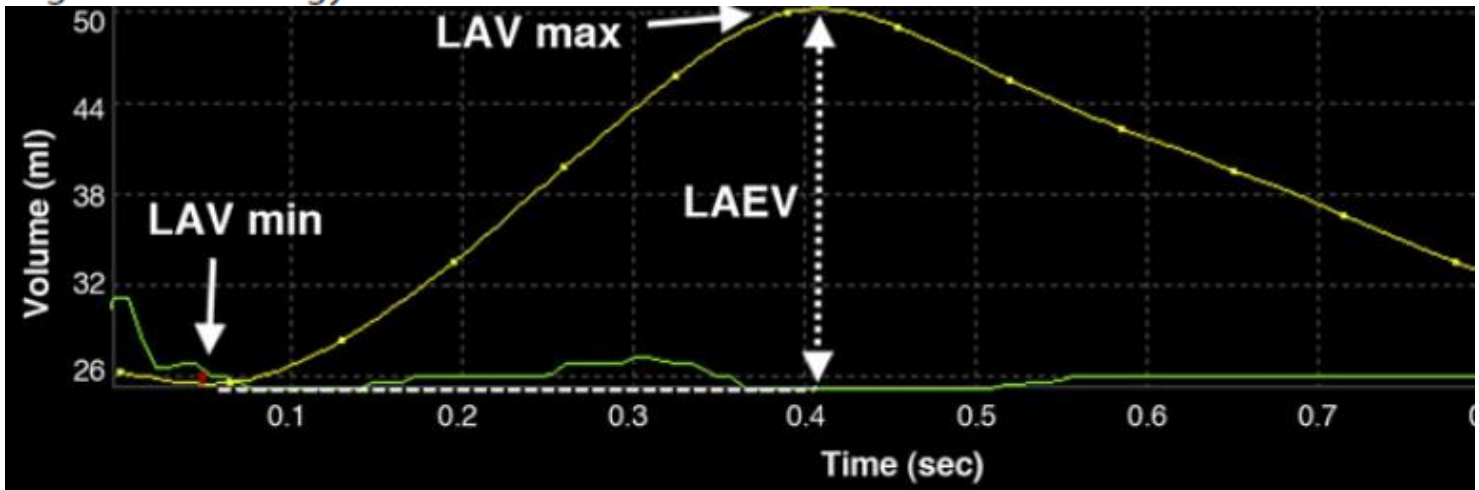
Xu. Circulation. 2004; 109: 363-8

LA Volumes and Reservoir Function Are Associated With Subclinical Cerebrovascular Disease

The CABL (Cardiovascular Abnormalities and Brain Lesions) Stu

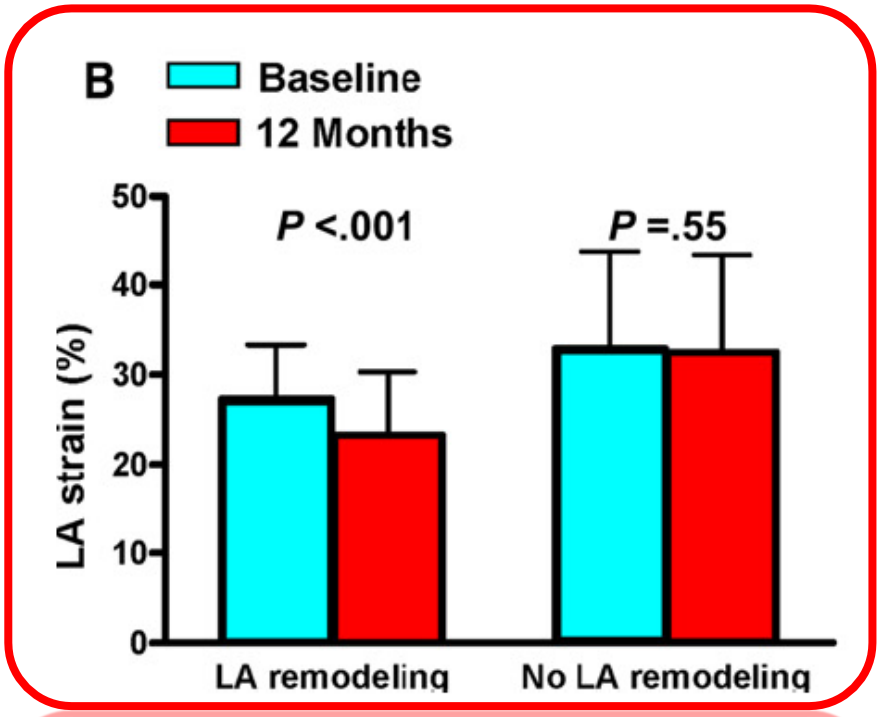


CONCLUSIONS Greater LA volumes and reduced LA reservoir function are associated with subclinical cerebrovascular disease detected by brain magnetic resonance imaging in subjects without history of stroke. In particular, LAV_{min} and LAEF are more strongly associated with SBI and WMHV than the more commonly measured LAV_{max}, and their relationship with subclinical brain lesions is independent of other cardiovascular risk factors. (J Am Coll Cardiol Img 2013;6:313–24) © 2013 by the American College of Cardiology Foundation



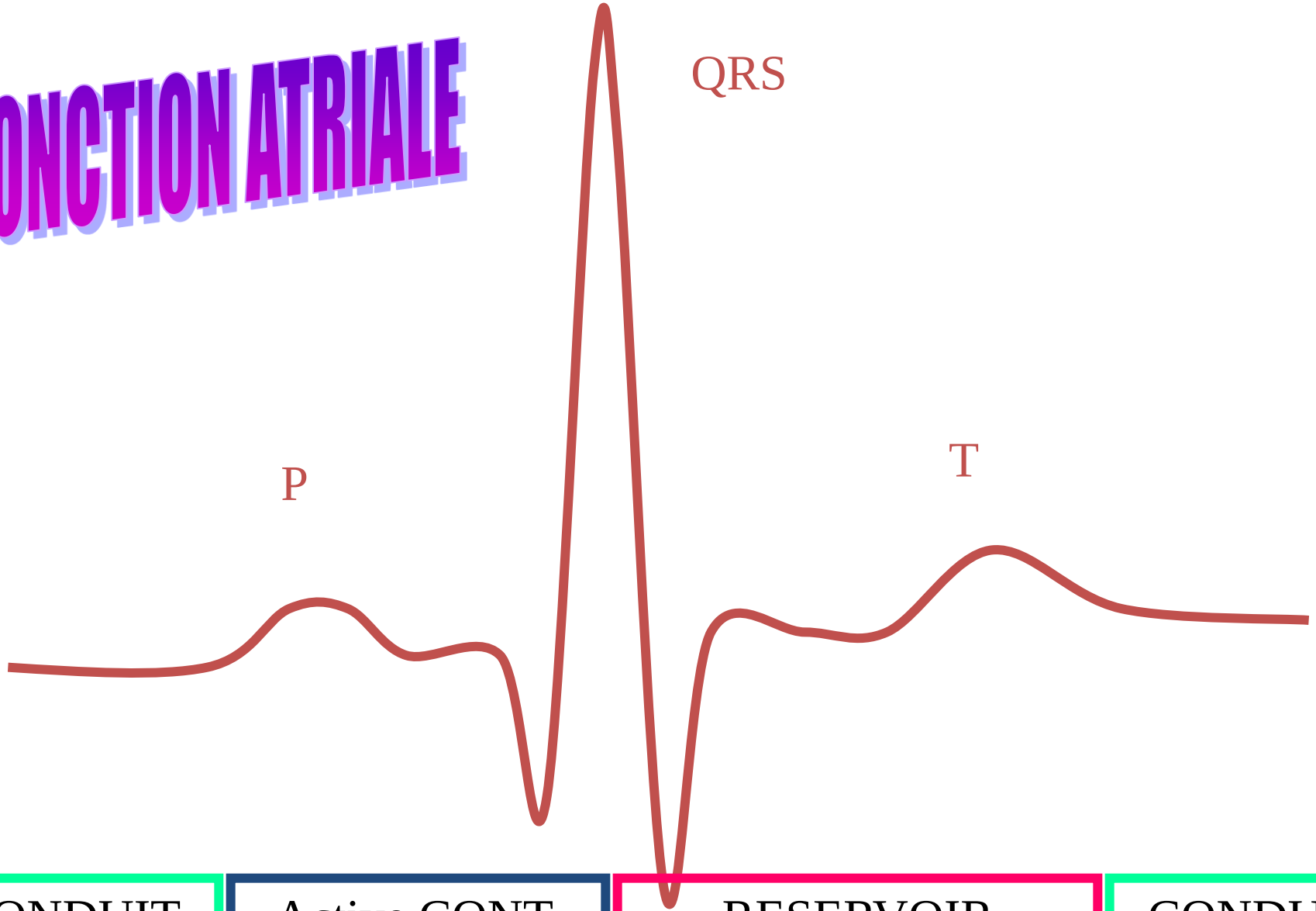
Comprehensive Assessment of Changes in Left Atrial Volumes and Function after ST-Segment Elevation Acute Myocardial Infarction: Role of Two-Dimensional Speckle-Tracking Strain Imaging

Methods: The study population comprised 407 patients with acute myocardial infarction who were treated with primary percutaneous coronary intervention. At baseline and 12 months, two-dimensional echocardiography was performed to assess LA volumes and function using speckle-tracking strain and strain rate.



Conclusions: LA remodeling occurred in 22% of patients after acute myocardial infarction. In patients without LA remodeling, no changes in LA function were observed, but in patients with LA remodeling, LA function deteriorated significantly. (J Am Soc Echocardiogr 2011;24:1126-33.)

FONCTION ATRIALE



CONDUIT	Active CONT.	RESERVOIR	CONDUIT

Localisations des thrombi en ETO lors de la fibrillation atriale
Méta-analyse de Mahajan

Compilations de 34 études de patients en FA

Le thrombus était en dehors de l'auricule gauche dans

- 56% des cas dans la FA valvulaire
- 22% des cas dans les cohortes mixtes
- 11% des cas de patients ayant une FA non valvulaire

Importance de la dysfonction ventriculaire gauche qui est associée au risque d'avoir un thrombus dans l'auricule gauche mais aussi en dehors !

Mhajan et al. Heart 2012; 98: 1120