



Nouveaux paramètres en échographie cardiaque

Mikhail Altman

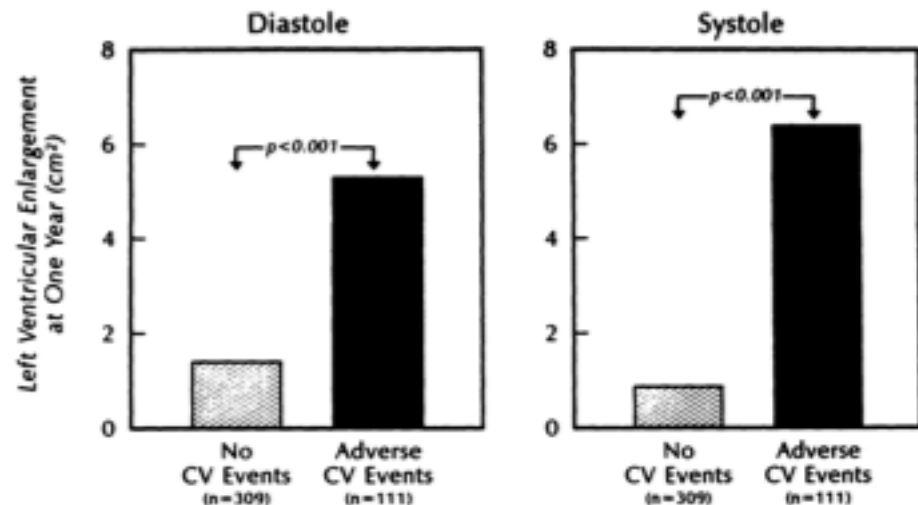
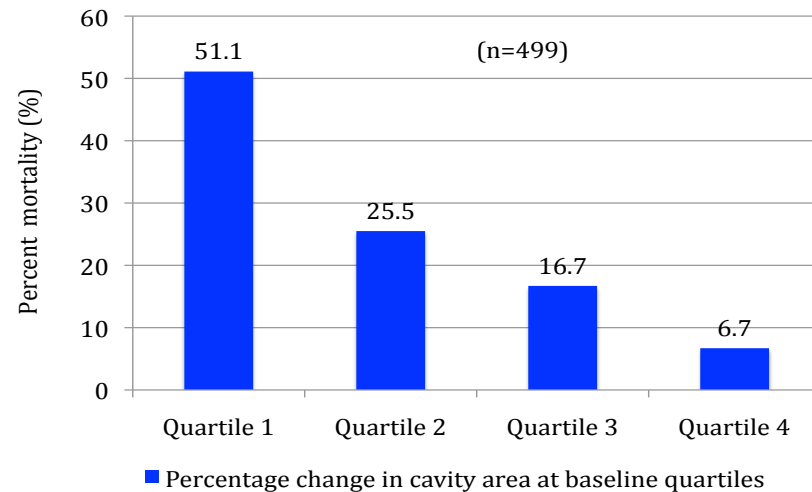
Hôpital cardiologique Louis Pradel (Lyon)

- Je vais focaliser sur les paramètres de la déformation qui sont disponibles en échographie cardiaque
- Je vais utiliser quatre cas cliniques pour montrer l'application et l'utilité de ces paramètres chez les patient avec cardiomyopathie ischémique et valvulaire

Les volumes et la fraction d'éjection – l'évaluation globale

- Depuis plusieurs années
- Facile avec une bonne reproductibilité
- Bien établi la relation avec le pronostic mauvais

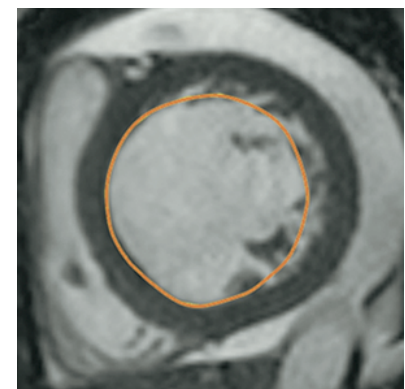
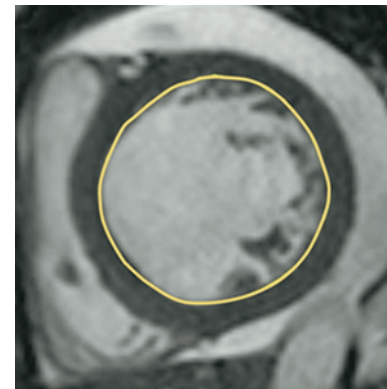
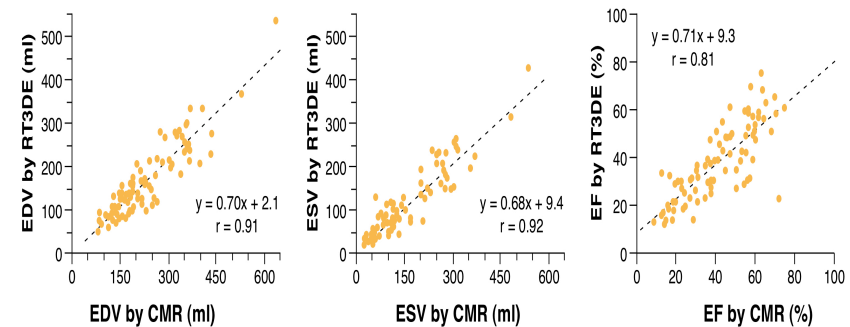
- Fonction radiale



MJ Sutton. Circulation 1994;89: 68-75

Les volumes et FEVG en 3D

- Méthode rapide
- Bonne corrélation avec IRM
- Plus précise et reproductible que 2D
- Les valeurs sont proches de celles d'IRM (mais parfois sous estimées)



Mor-Avi V. JACC Cardiovasc Imaging, 2008;4:13-23

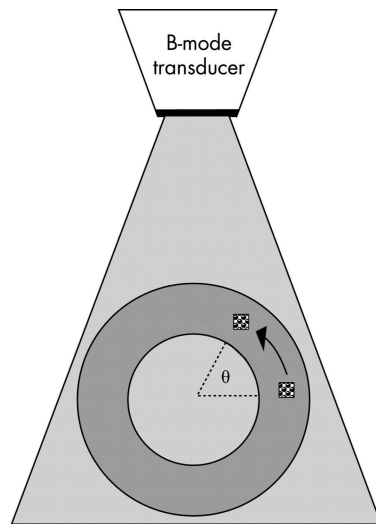
EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

Currently, 3D TTE and TEE assessment of LV volumes and ejection fraction is recommended over the use of 2D echocardiography, as it has been clearly demonstrated to provide more accurate and reproducible measurements.

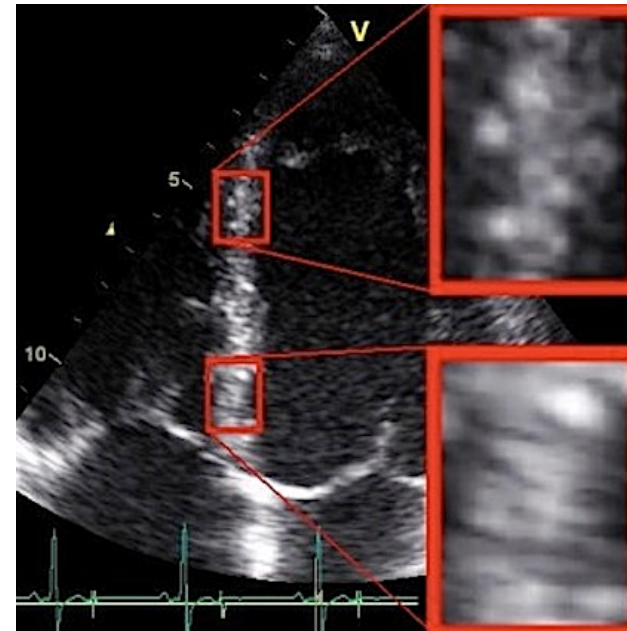
Lang R, J Am Soc Echocardiogr 2012;25;3-46

Strain – l'évaluation régionale et globale de la fonction systolique

Speckle tracking



Pas de dépendance de l'angle

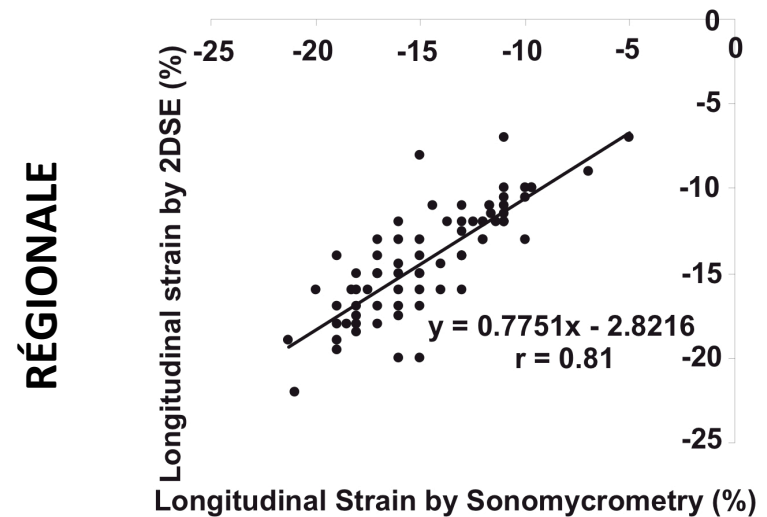


Asbjørn Støylen, NTNU, Trondheim

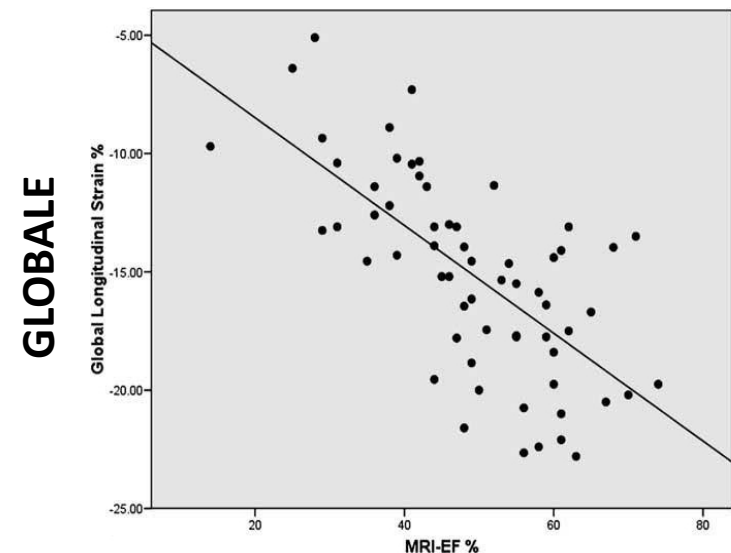
Plus dépendant de la qualité de l'image 2D

Strain longitudinal

- Bien étudié, plus validé
- Bonne corrélation entre le strain longitudinal et la fonction systolique régionale et globale
- Bonne reproductibilité < 10%



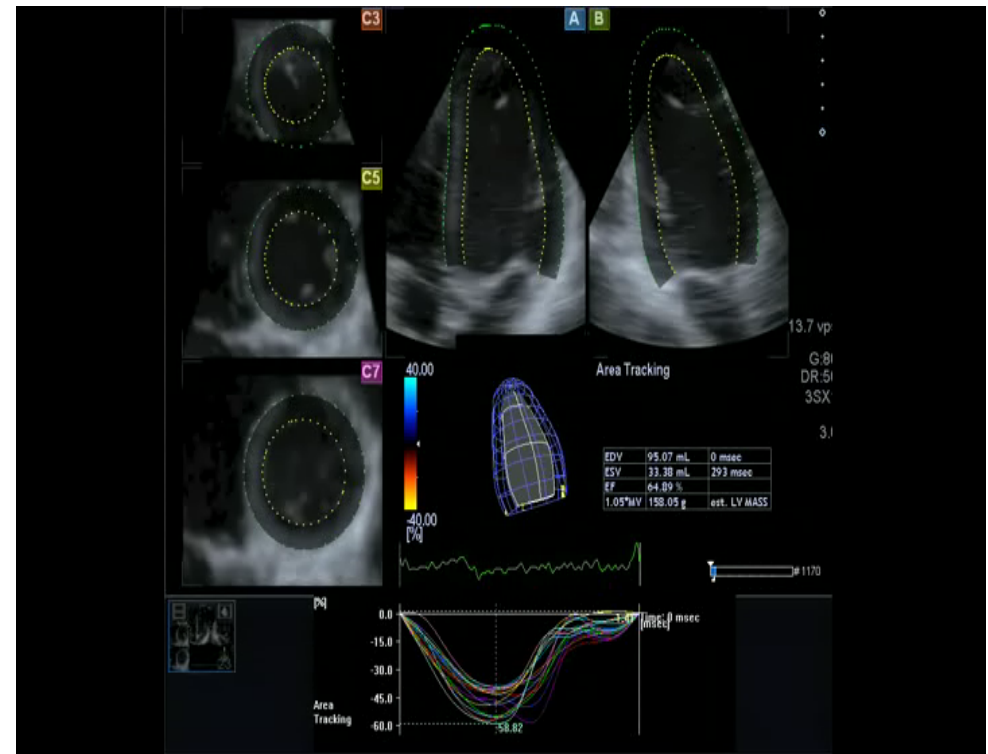
P Reant, J Am Coll Cardiol 2008;51:149057



J Brown, Am Heart J 2009;157:102

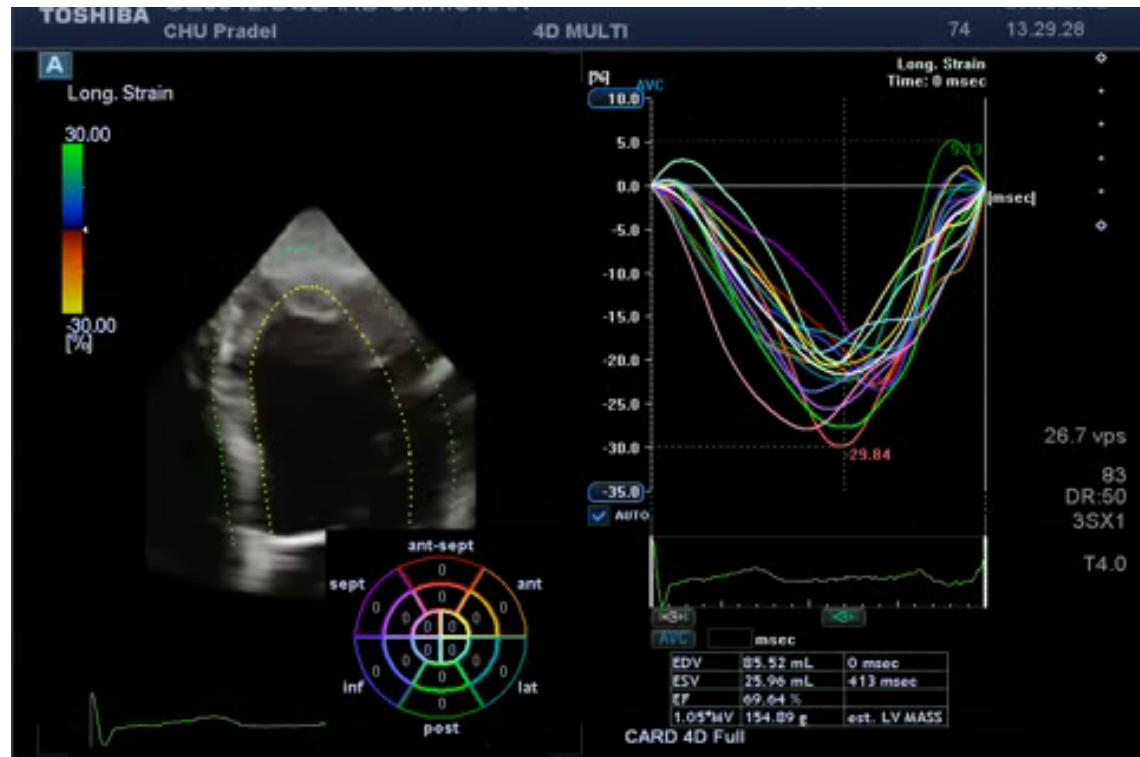
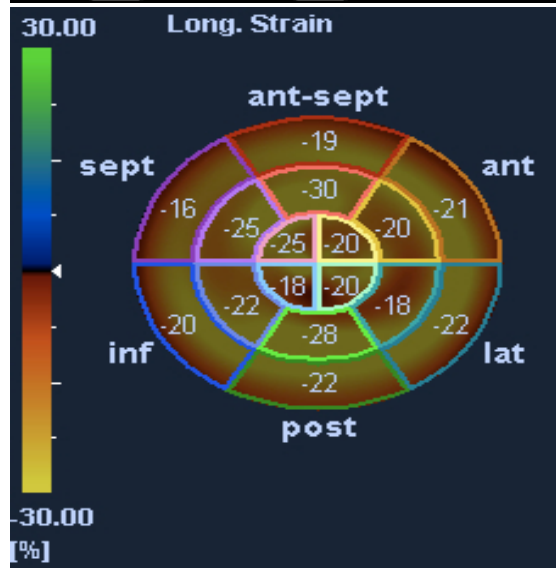
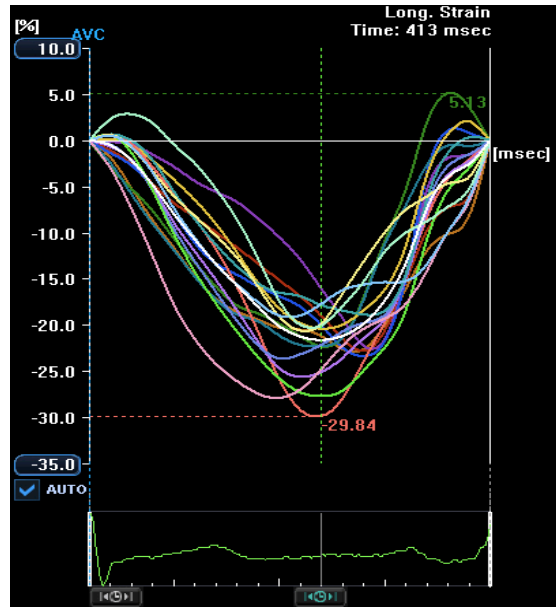
Les strains en 3D

- L'évaluation plus rapide
- L'évaluation dans le même cycle cardiaque
- Elimination potentielle d'effet de «out of plane» mouvement
- Disponibilité des nouveaux paramètres comme Area Tracking ou Area strain



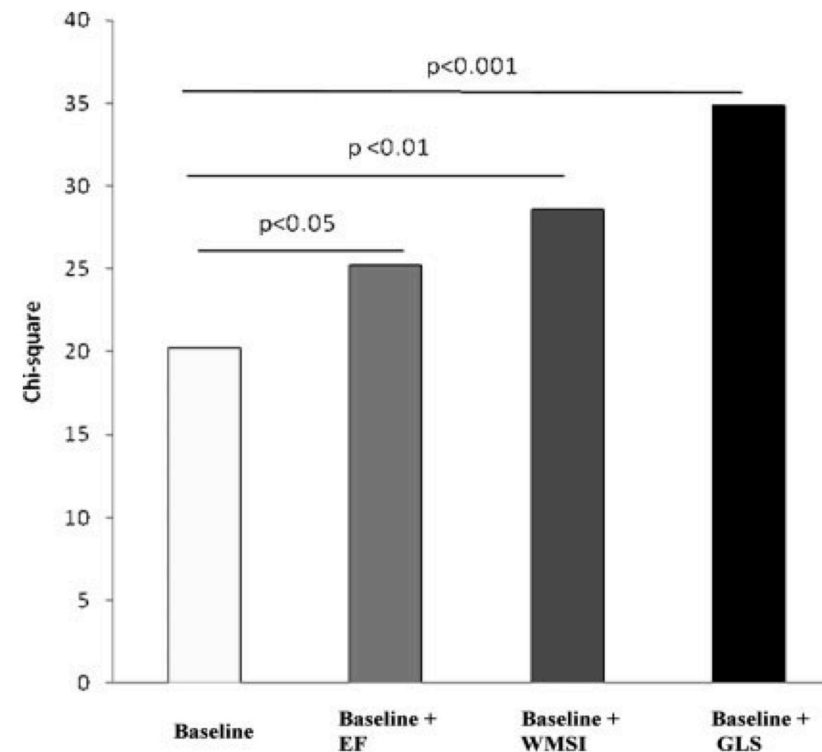
La cadence plus bas que en 2D

Strain longitudinal 3D – valeurs régionales et globales



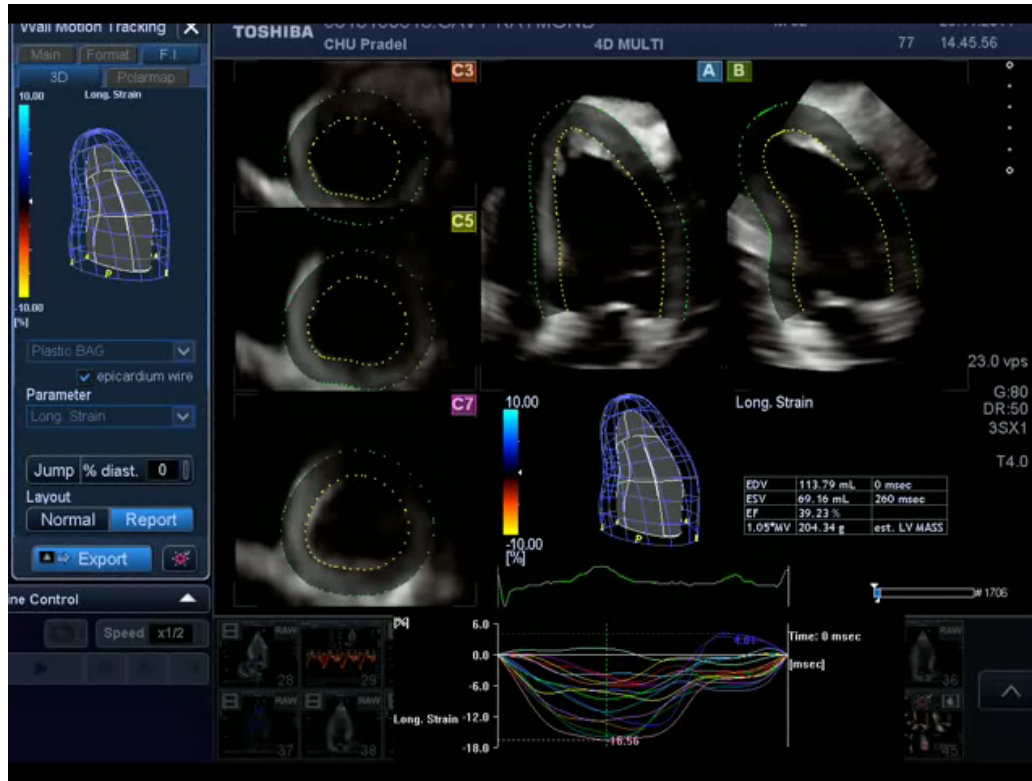
SLG – un facteur pronostique

- La puissance de la prédiction des conséquences négatives (mortalité) est supérieure de celles-là de FEVG et WMSI

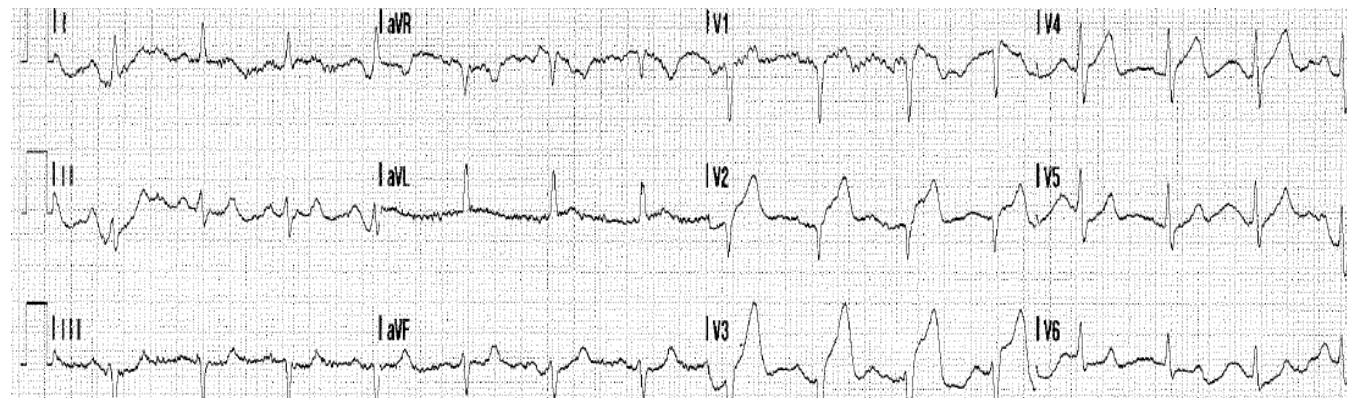


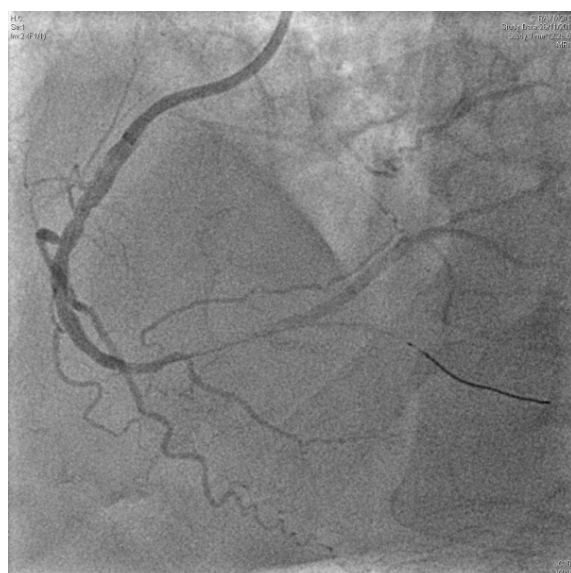
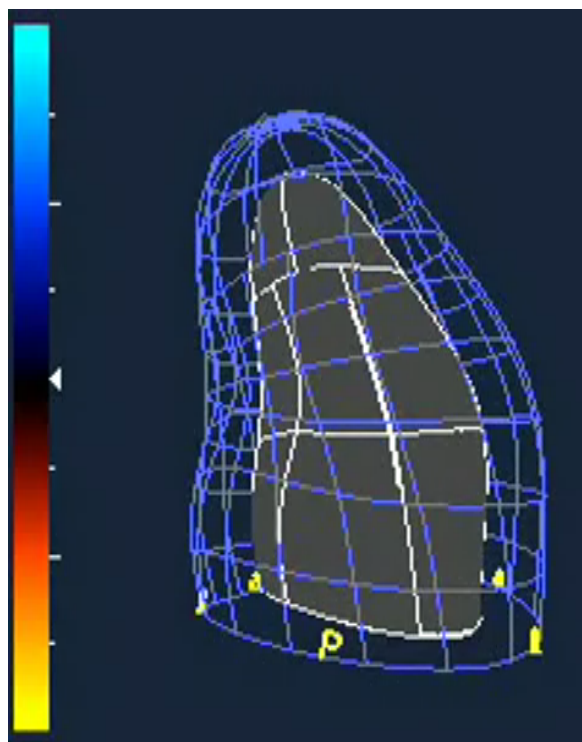
T Stanton, Circ Cardiovasc Imaging 2009;2:356-64

Cardiomyopathie ischémique



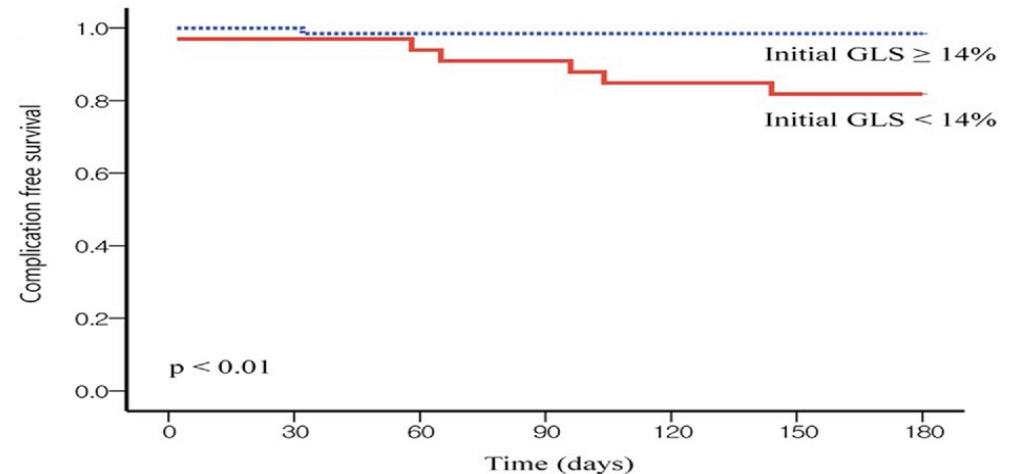
- 62 ans
- Inaugural
- Antero-septale



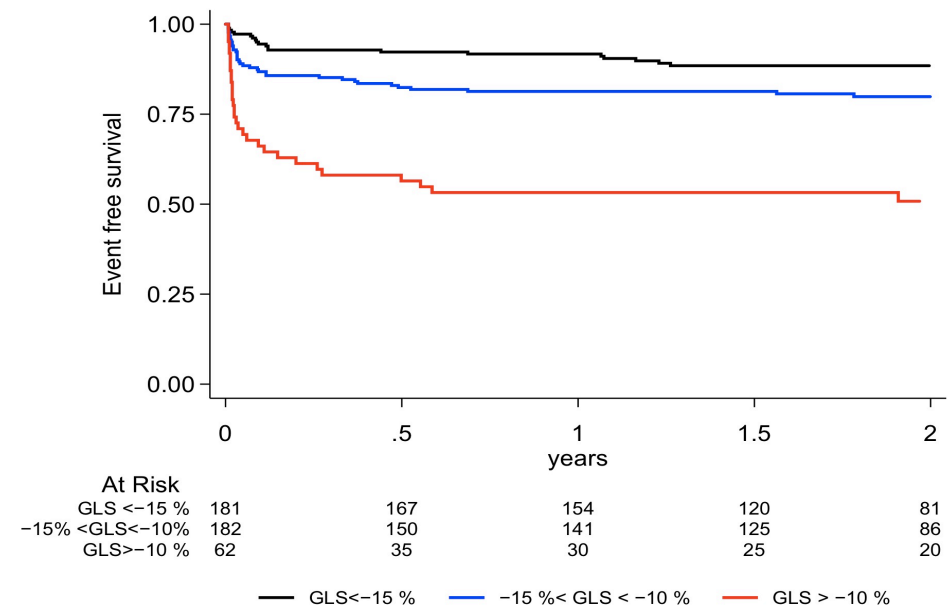


Strain longitudinal globale

- Un strain longitudinal globale préservé lors d'une phase aigue de l'infarctus est associe avec une meilleure survie sans événements



JS Woo, Am J Cardiol 2011; 108:340-47

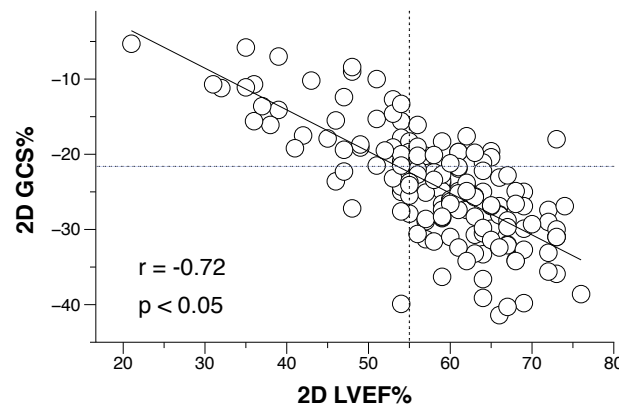


K Munk, JASE 2012; 25:644-51

Autres paramètres du strain

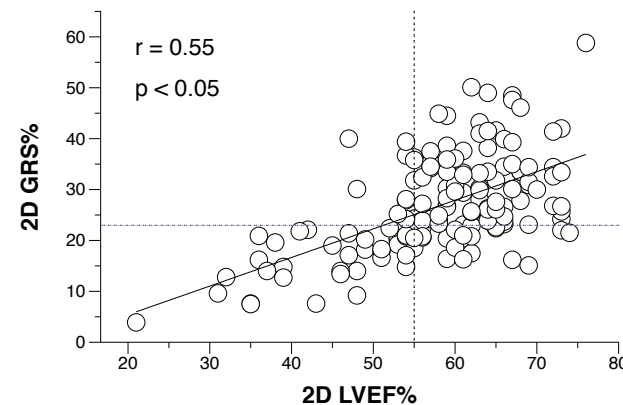
Strain circonférentiel

- Les données plus limitées
- Selon quelques-uns études il y a une association assez forte avec FEVG
- Reproductibilité > 10%

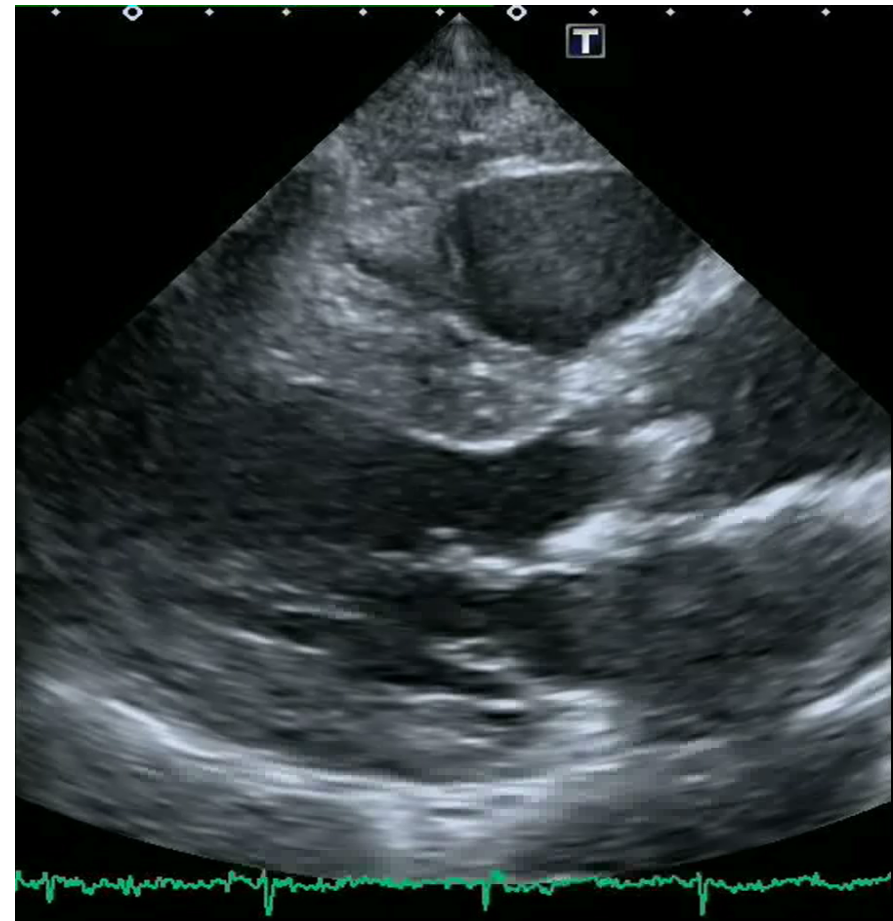


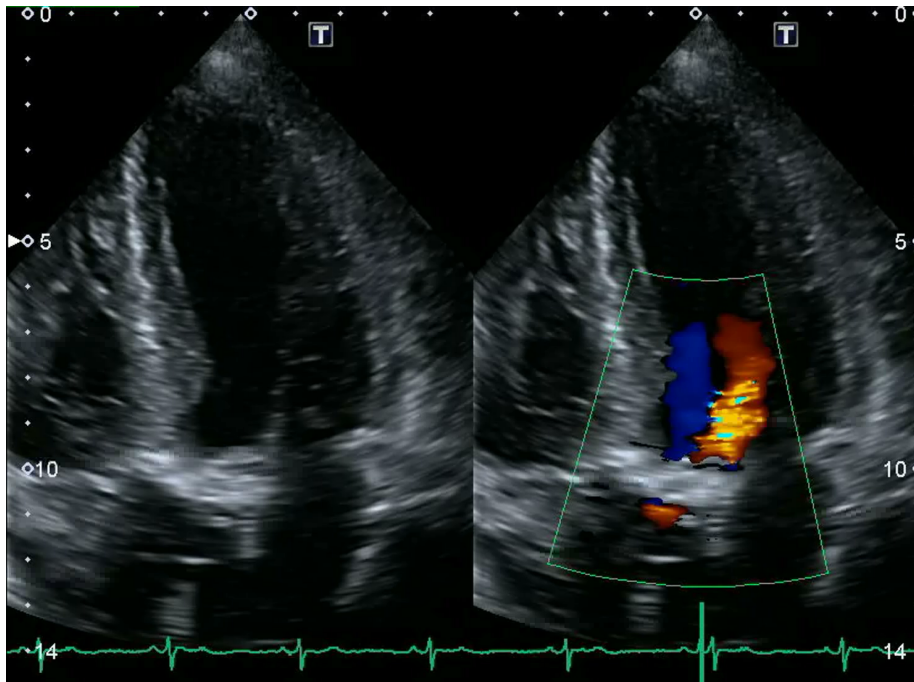
Strain radiale

- Le moins étudié
- Grande variabilité entre opérateurs
- Moins précise corrélation avec FEVG
- Reproductibilité > 15-20%



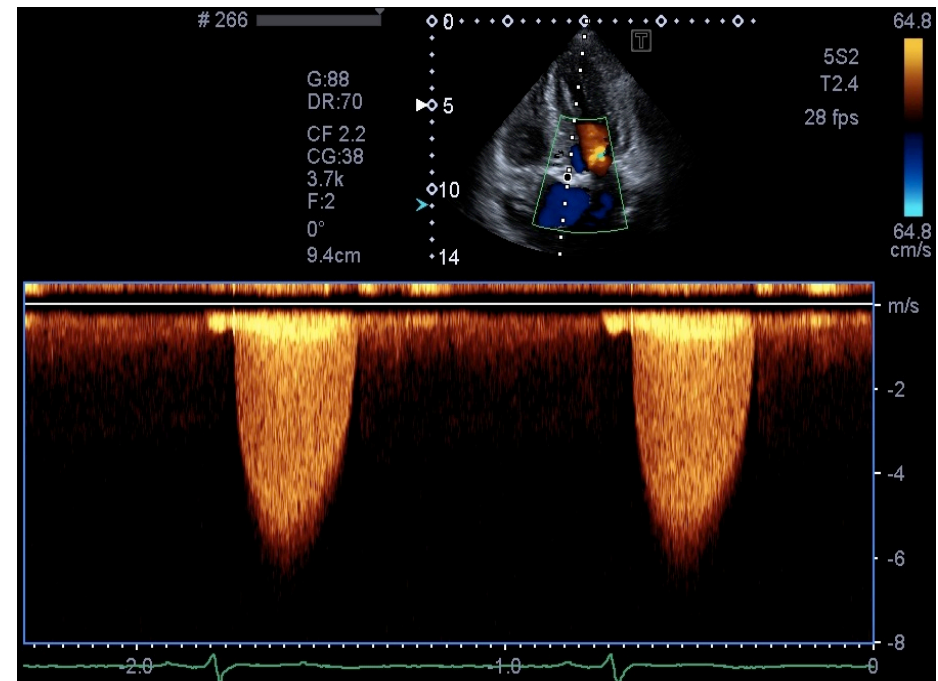
Rétrécissement Aortique





- Une femme de 45 ans
- Asymptomatique

- AV max 6 m/s
- Gradient moyen 80 mm Hg



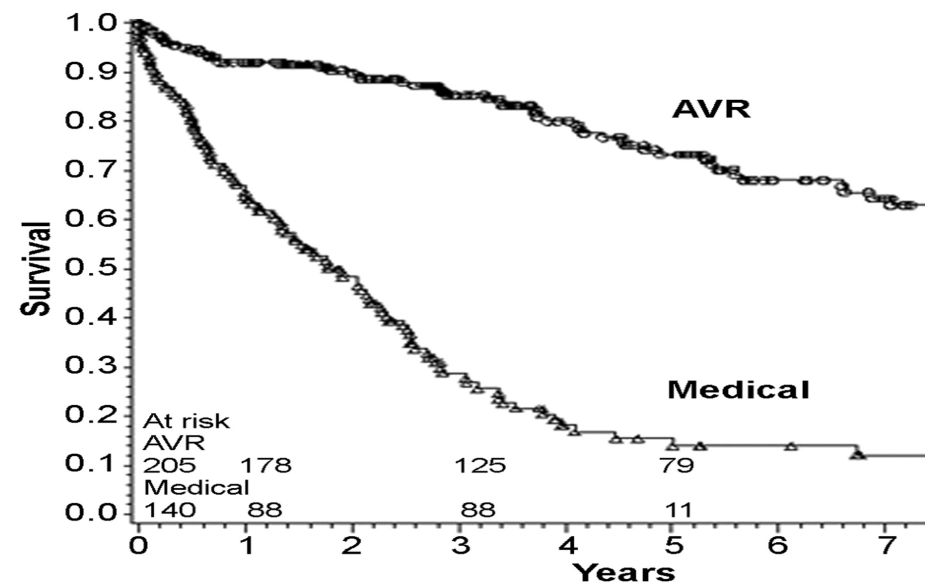
Rétrécissement aortique

Total population n=5001		
Native valve disease (%)	71.9	
Aortic (% native)	44.3	
Aortic stenosis (%)		33.9
Aortic regurgitation (%)		10.4
Mitral (% native)	34.3	
Mitral stenosis (%)		9.5
Mitral regurgitation (%)		24.8
Multiple (% native)	20.2	
Right (% native)	1.2	
Previous intervention (%)	28.1	
Conservative surgery (%)	18.4	
Valve replacement (%)	81.6	

- RA la plus fréquente valvulopathie en Europe

B. Iung, European Heart Journal, 2003

- Chez les patients avec un RA sévère la survie est plus favorable dans le groupe chirurgical



F. Bakaeen, The annals of Thorac Surgery 2010

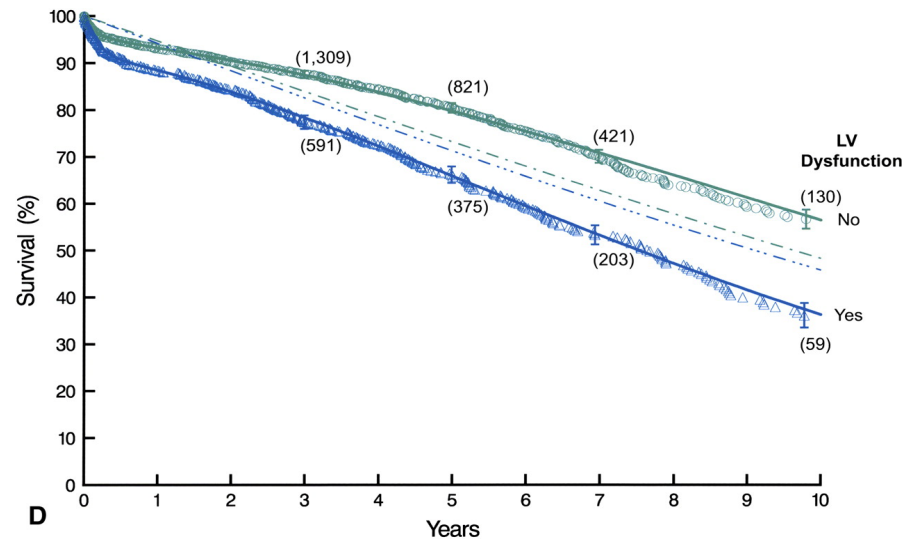
Rétrécissement aortique

Indications à l'intervention chirurgicale

1. Sévère RA avec des symptômes associés
2. Sévère RA sans symptômes et FEVG < 50%

	Class ^a	Level ^b
AVR is indicated in patients with severe AS and any symptoms related to AS.	I	B
AVR is indicated in patients with severe AS undergoing CABG, surgery of the ascending aorta or another valve.	I	C
AVR is indicated in asymptomatic patients with severe AS and systolic LV dysfunction (LVEF <50%) not due to another cause.	I	C
AVR is indicated in asymptomatic patients with severe AS and abnormal exercise test showing symptoms on exercise clearly related to AS.	I	C

Guidelines on the management of the valvular heart disease (version 2012) ESC and EACTS



T. Mihaljevic, J Thorac Cardiovasc Surg 2008

- La survie est plus bas après le remplacement si FEVG < 50%
- Est-ce que FEVG normale veut dire que la fonction systolique est normale?

Rétrécissement aortique

Table 2 Baseline multidirectional left ventricular strain and strain rate values in severe aortic stenosis patients, healthy controls, and hypertensive patients with left ventricular hypertrophy

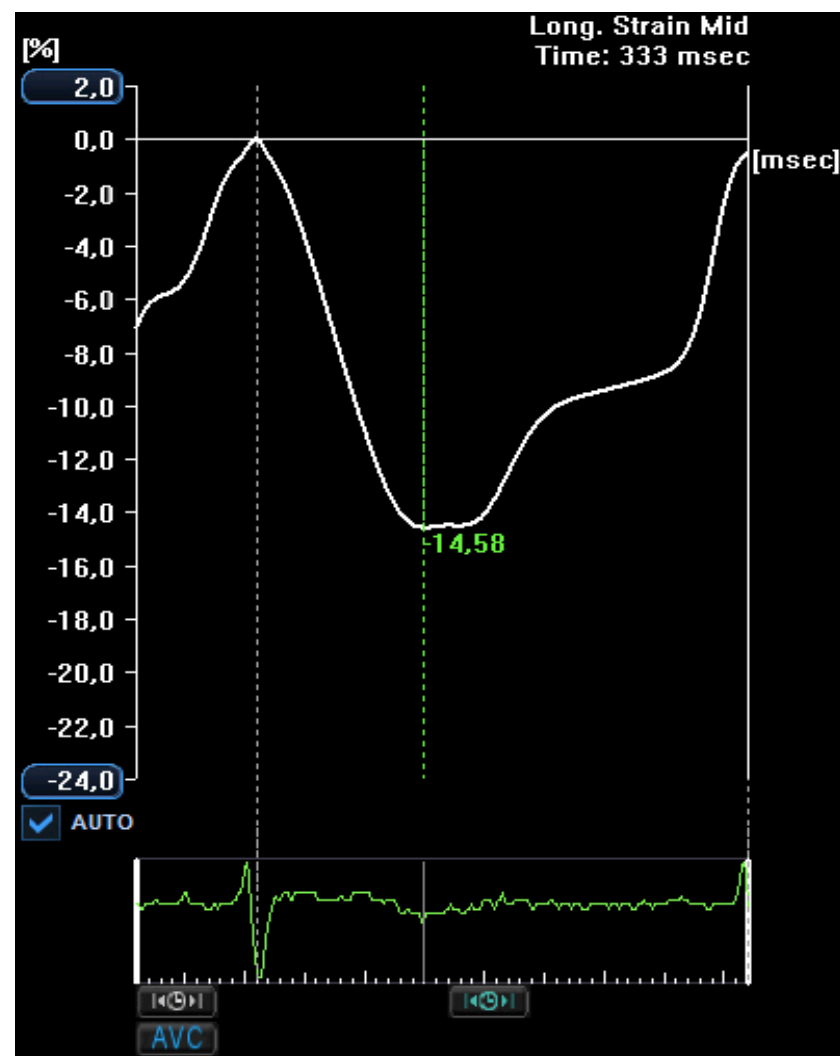
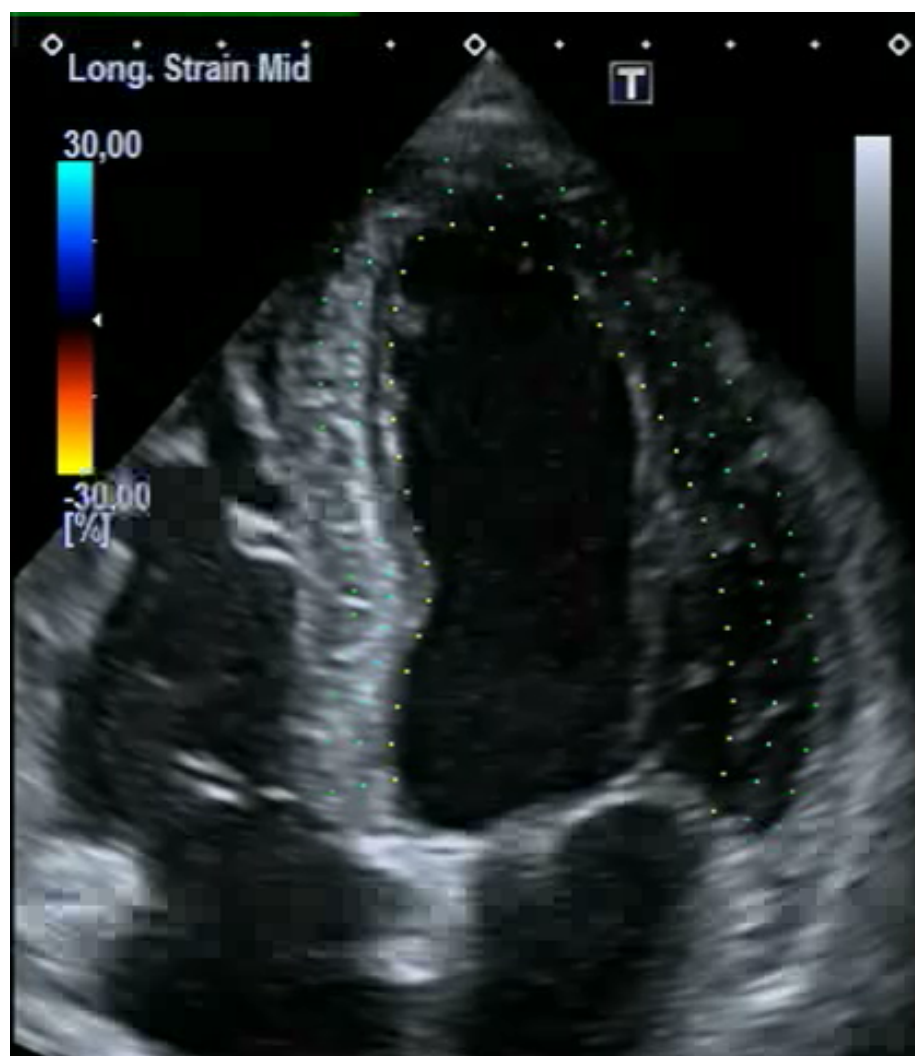
	Healthy controls (n = 20)	LV hypertensive patients (n = 20)	AS patients (n = 73)	ANOVA P-value
Age (years)	65 ± 8	66 ± 9	65 ± 13	0.95
BSA (m ²)	1.9 ± 0.1	1.9 ± 0.1	1.9 ± 0.2	0.56
LV mass index (g/m ²)	109 ± 28* [§]	144 ± 33	157 ± 49	<0.0001
LVEF (%)	62 ± 7	61 ± 7	61 ± 11	0.91
Radial strain (%)	38.9 ± 6.4	34.4 ± 10.7	33.1 ± 14.8	0.2
Radial strain rate (s ⁻¹)	2.2 ± 0.6 [†]	1.8 ± 0.5	1.7 ± 0.5	0.003
Circumferential strain (%)	-19.5 ± 2.9 [†]	-17.0 ± 3.0	-15.2 ± 5.0	0.001
Circumferential strain rate (s ⁻¹)	-1.3 ± 0.3* [§]	-1.1 ± 0.3 [‡]	-0.9 ± 0.3	<0.001
Longitudinal strain (%)	-20.3 ± 2.3*	-17.2 ± 3.7 [‡]	-14.6 ± 4.1	<0.001
Longitudinal strain rate (s ⁻¹)	-1.1 ± 0.2*	-0.9 ± 0.2 [‡]	-0.8 ± 0.2	<0.001

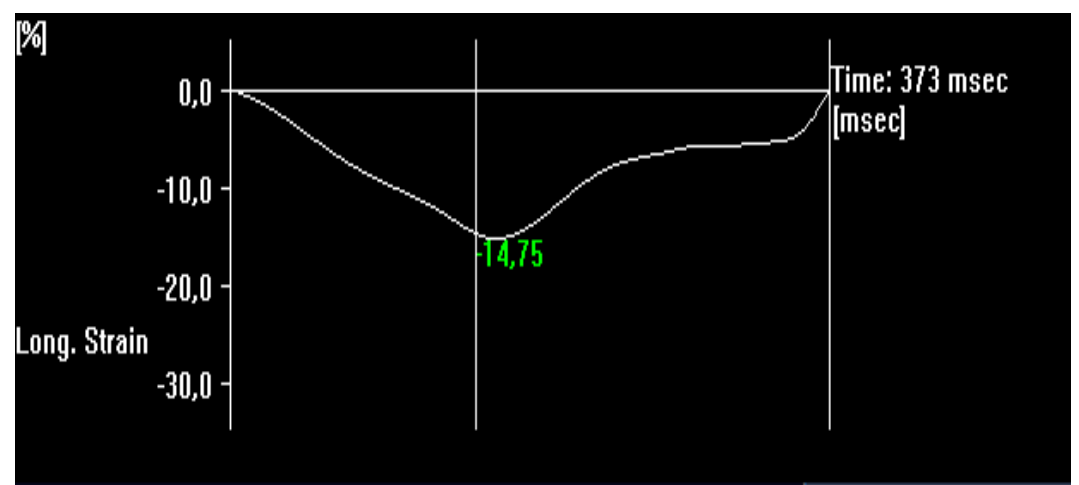
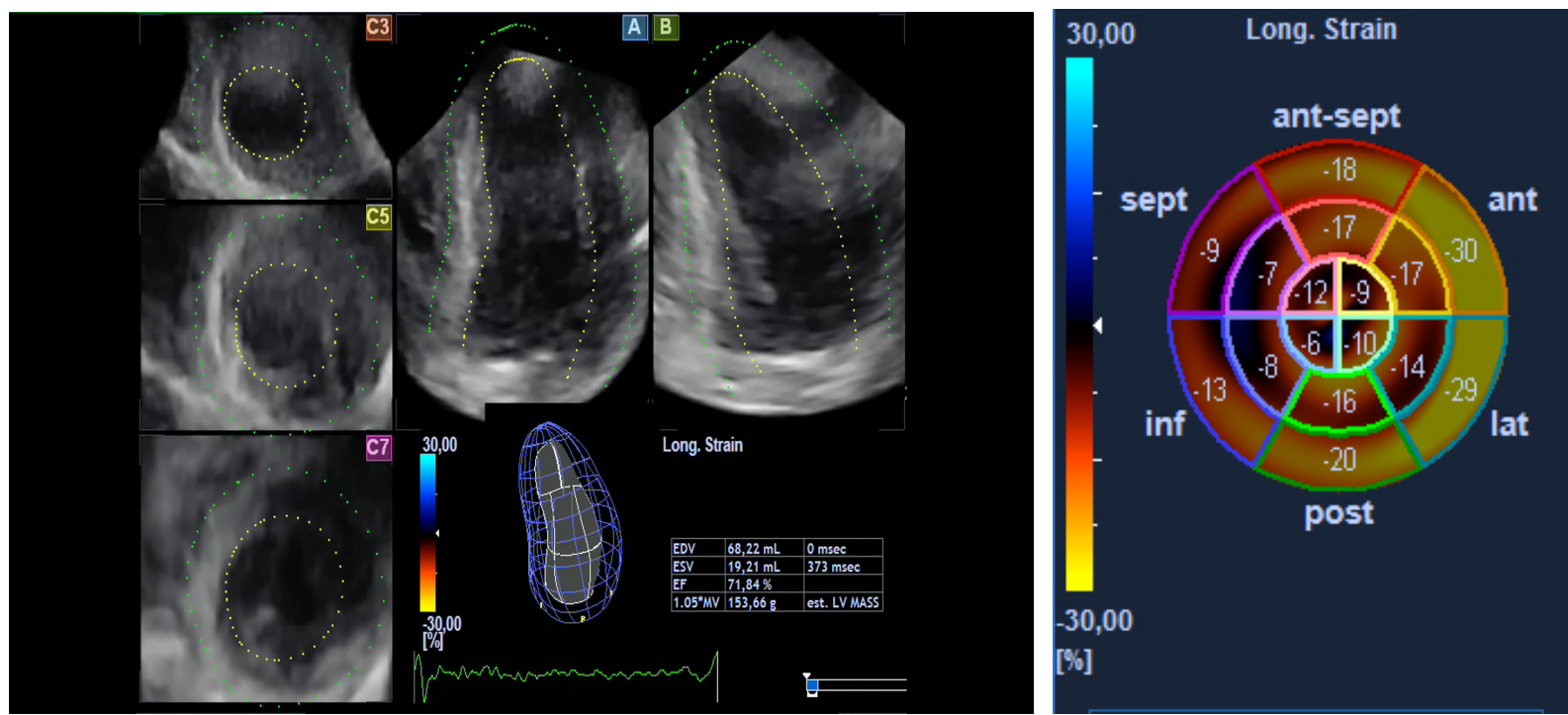
V. Delgado, European Heart Journal, 2009

Variable	AS			Control (n = 20)	P
	Mild (n = 10)	Moderate (n = 15)	Severe (n = 48)		
LVEF (%)	63 ± 5	61 ± 2	61 ± 4	62 ± 4	.53
MWFS (%)	16 ± 3	15 ± 3*	14 ± 3* ^{†,‡}	18 ± 3	<.001
E/E' ratio	12 ± 3	15 ± 10	22 ± 8* ^{†,‡}	11 ± 4	<.001
LV mass index (g/m ²)	78 ± 15	104 ± 20*	137 ± 31* ^{†,‡}	75 ± 21	<.001
AVA (cm ²)	1.6 ± 0.5	1.1 ± 0.1 [†]	0.7 ± 0.2 ^{†,‡}	—	—
Peak PG (mm Hg)	29 ± 11*	50 ± 19* [†]	82 ± 24* ^{†,‡}	9 ± 3	<.001
Mean PG (mm Hg)	16 ± 8*	30 ± 12* [†]	48 ± 17* ^{†,‡}	5 ± 2	<.001
Longitudinal strain (%)	-18 ± 3	-17 ± 3*	-14 ± 3* ^{†,‡}	20 ± 3	<.001

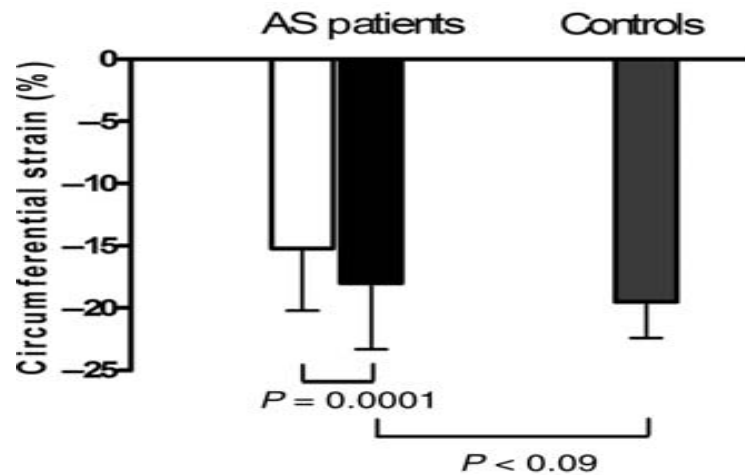
E. Hyodo, J Am Soc Echocardiography, 2012

- FEVG normale
- Paramètres de la déformation diminués
- Strain longitudinal s'est diminué plus tôt
- Corrélation linéaire avec la sévérité de RA



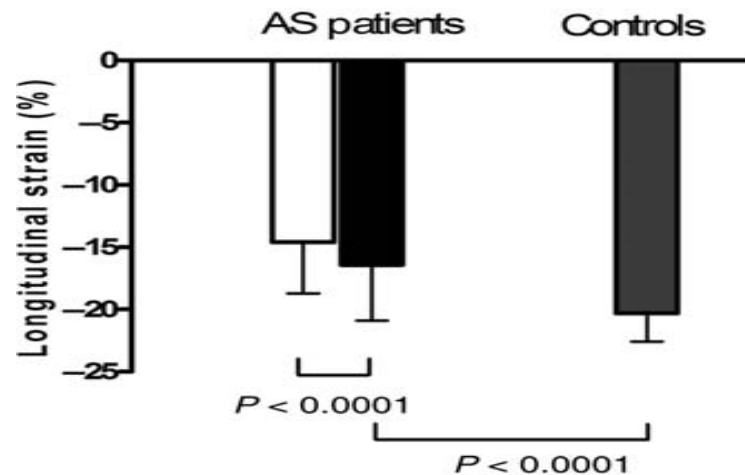


Rétrécissement aortique



Après le remplacement de la valve aortique

- Pas de changement de FEVG (60%)
- Amélioration de paramètres de la déformation
- Strain circonférentiel augment vers les valeurs normales
- Strain longitudinal augment mais il ne rattrape pas les valeurs normales



Baseline—AS patients



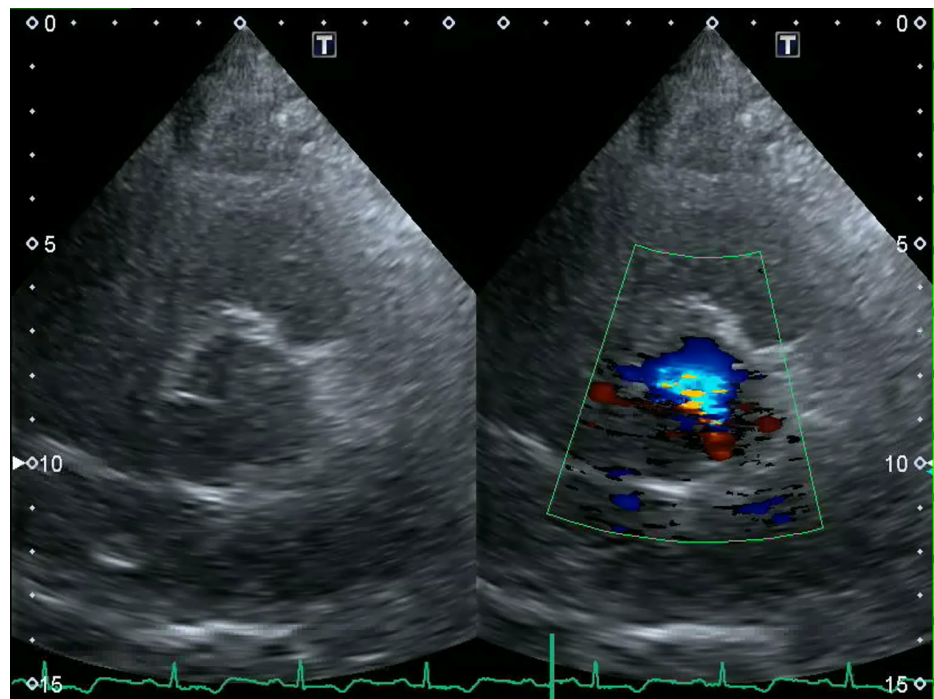
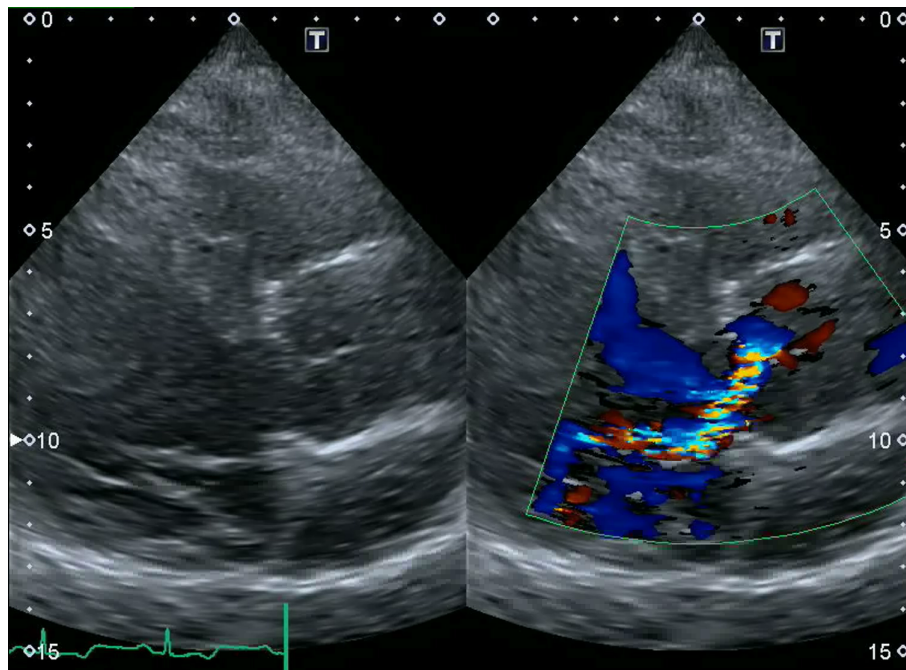
Follow-up—AS patients



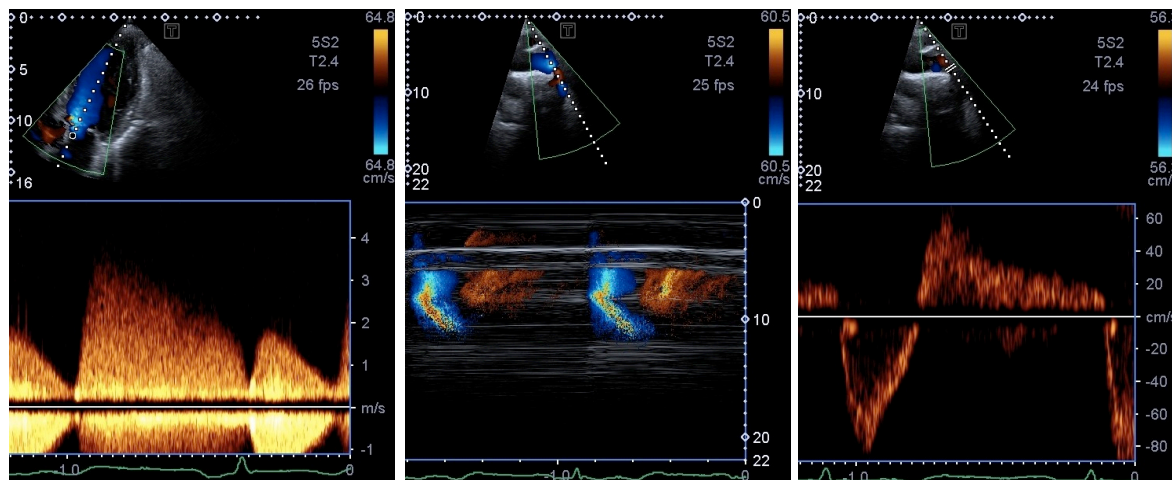
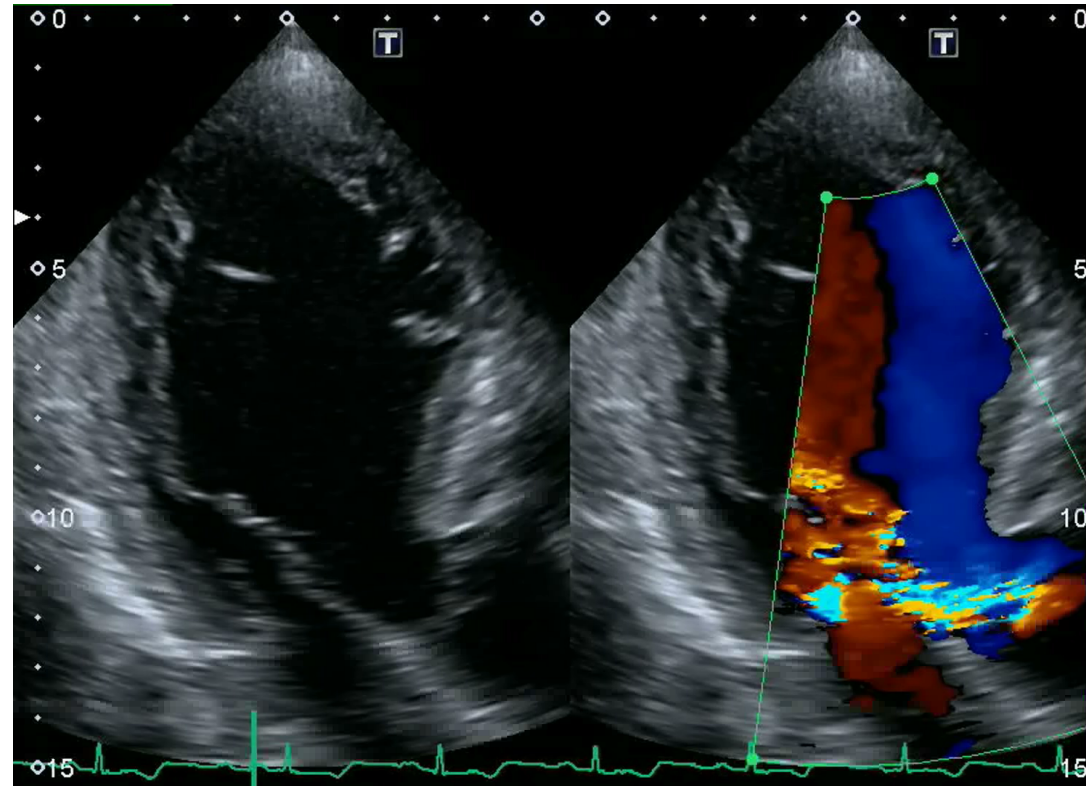
Controls



Insuffisance aortique



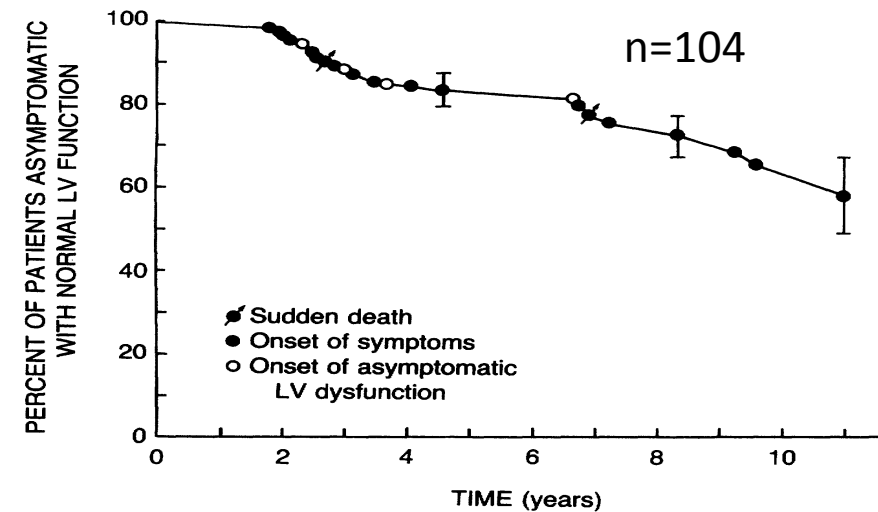
- Un homme de 72 ans
- Symptomatique



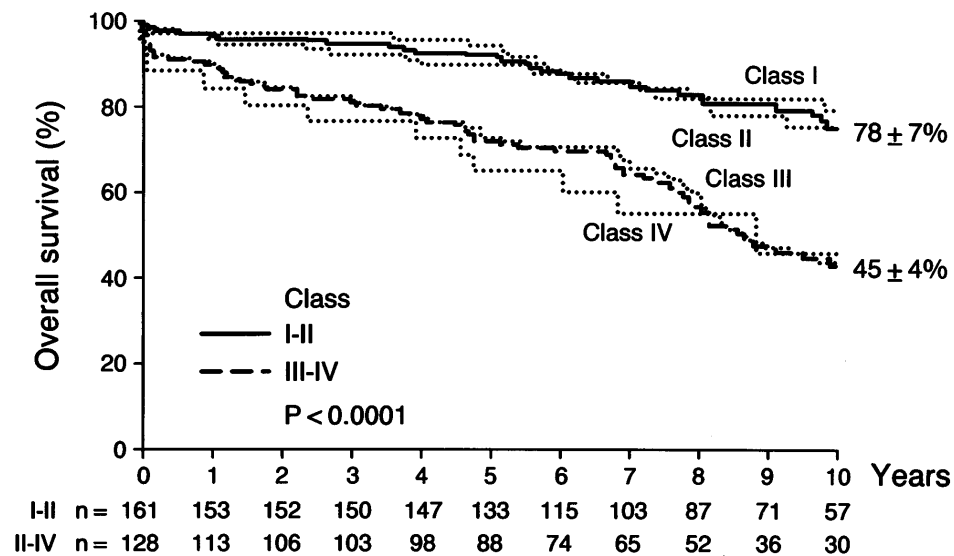
- Vena contracta 0.7 cm
- Inversion holodiastolique du flux aortique (arche)
- Vitesse telediastolique 0.2 m/s (arche)

Insuffisance aortique

- Chez les patients asymptomatiques avec FEVG normale: à 11 ans presque 60% restent asymptomatiques



R. Bonow, Circulation 1991



E. Klodas, JACC 1997

- Chez les patients symptomatiques la survie est moins favorable si les symptômes sont plus accentués

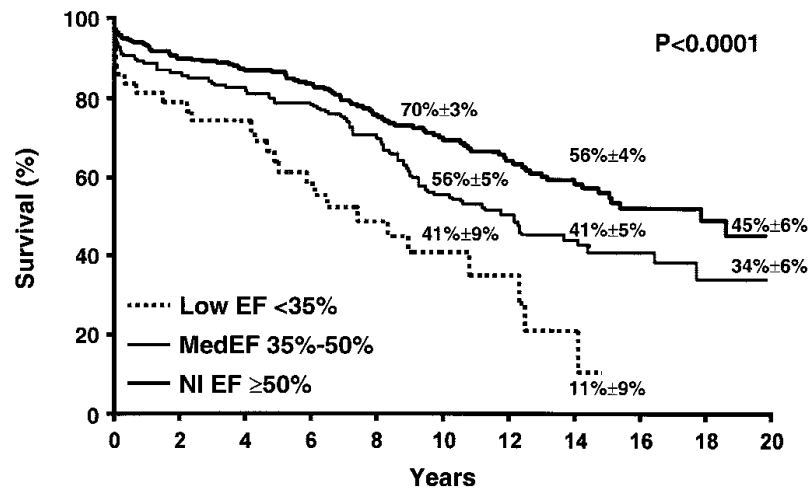
Insuffisance aortique

- Sévère IA avec des symptômes associés
- Sans symptômes mais FEVG $\leq 50\%$

Indications à l'intervention chirurgicale

	Class ^a	Level ^b
A. Indications for surgery in severe aortic regurgitation		
Surgery is indicated in symptomatic patients.	I	B
Surgery is indicated in asymptomatic patients with resting LVEF $\leq 50\%$.	I	B
Surgery is indicated in patients undergoing CABG or surgery of ascending aorta, or on another valve.	I	C
Surgery should be considered in asymptomatic patients with resting EF $>50\%$ with severe LV dilatation: LVEDD >70 mm, or LVESD >50 mm or LVESD >25 mm/m ² BSA. ^d	IIa	C

Guidelines on the management of the valvular heart disease (version 2012) ESC and EACTS



LoEF (EF $<35\%$)	43	35	31	21	15	8	6	3		
MedEF (EF 35%-50%)	134	115	108	95	78	50	34	30	19	9
NI EF (EF $\geq 50\%$)	273	245	231	184	141	112	83	60	32	17

- Chez les patients avec une dysfonction VG la survie est moins favorable

H. Chaliki, Circulation 2002

Insuffisance aortique

- Strain longitudinal global diminué même si FEVG > 50%

Longitudinal Systolic Strain and Strain Rates of the Each Segment LVEF>50%							
VVI Analyses	Patients	Inferior Septum	Lateral	Anterior Septum	Posterior	Anterior	Inferior
Strain Rate (s ⁻¹)	AR patients	0.86 ± 0.11	0.95 ± 0.15	0.95 ± 0.18	0.87 ± 0.10	0.88 ± 0.13	0.90 ± 0.18
	Control	1.5 ± 0.19	1.49 ± 0.18	1.5 ± 1.84	1.5 ± 0.18	1.53 ± 0.15	1.55 ± 0.18
Strain (%)	n=40 AR patients	16.25 ± 2.53	18.12 ± 3.03	18.24 ± 3.39	16.09 ± 2.34	16.85 ± 3.0	16.78 ± 3.0
	n=30 Control	21.7 ± 3.76	24.2 ± 3.01	24.15 ± 3.25	24.3 ± 2.56	24.29 ± 2.9	24.15 ± 3.26

*P < 0.0001. Control group versus patients with AR in each segment.

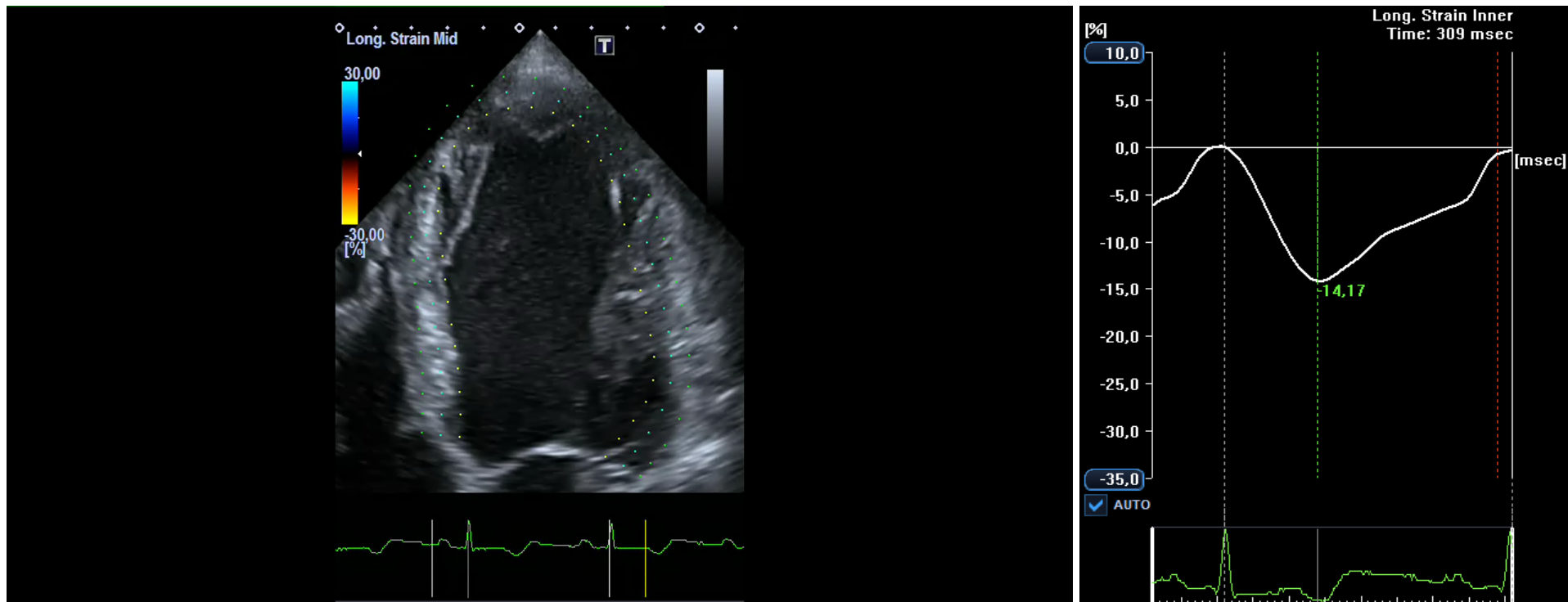
Y. Tayyareci, Echocardiography 2010

- La différence significative entre sujets normaux et les patients avec IA sévère

Les valeurs absolues du strain longitudinal global

	Control (n = 22)	Mild AR (n = 10)	Moderate AR (n = 13)	Severe AR (n = 36)
Apical four-chamber				
Septum (%)	21 ± 6	21 ± 4	18 ± 3	14 ± 6*
LV lateral wall (%)	21 ± 5	22 ± 4	19 ± 4	15 ± 5*

A. Marciniak, European J Echocardiography 2009



- Patient a refusé l'intervention chirurgicale
- Diminution de FEVG de 60% à 50% dans 9 mois

Insuffisance aortique

Table 2 Comparison of echocardiographic findings in patients and controls

Variable	Patients before surgery (n = 44)	P	Patients after surgery (n = 44)	Controls (n = 31)	P*	P†
Global longitudinal strain (%)	-17.5 ± 3.1	.01	-16.1 ± 3.1	-22.1 ± 1.8	<.01	<.01
Normalized global longitudinal strain	-0.09 ± 0.04	<.01	-0.12 ± 0.04	-0.23 ± 0.08	<.01	<.01
Global circumferential strain (%)	-21.7 ± 3.4	.55	-21.1 ± 4.1	-22.6 ± 2.5	.22	.07
Normalized circumferential strain	-0.11 ± 0.05	<.01	-0.16 ± 0.06	-0.24 ± 0.08	<.01	<.01
Radial strain (%)	51.7 ± 18.5	.81	41.5 ± 16.6	59.4 ± 20.3	.14	<.01
Septal longitudinal velocity (cm/sec)	5.8 ± 1.4	<.01	4.8 ± 1.2	6.6 ± 0.8	.01	<.01
Lateral longitudinal velocity (cm/sec)	6.2 ± 1.6	<.01	7.2 ± 1.8	7.0 ± 1.6	.09	.479
Septal longitudinal displacement (cm)	11.4 ± 3.9	<.01	9.7 ± 3.0	13.7 ± 1.8	.03	<.01
Lateral longitudinal displacement (cm)	10.3 ± 3.3	<.01	12.5 ± 3.7	13.0 ± 2.4	<.01	.46
LVEF (%)	59 ± 5	<.01	54 ± 7	59 ± 6	.59	<.01
LV EDV (mL)	214 ± 71	<.01	141 ± 36	105 ± 30	<.01	<.01
LV ESV (mL)	93 ± 36	<.01	68 ± 24	43 ± 15	<.01	<.01

• Amélioration n'est pas toujours évident

• Changements irréversibles ??

M. Smedsrud, J Am Soc Echocardiography 2011

• Valeur prédictive des conséquences négatives

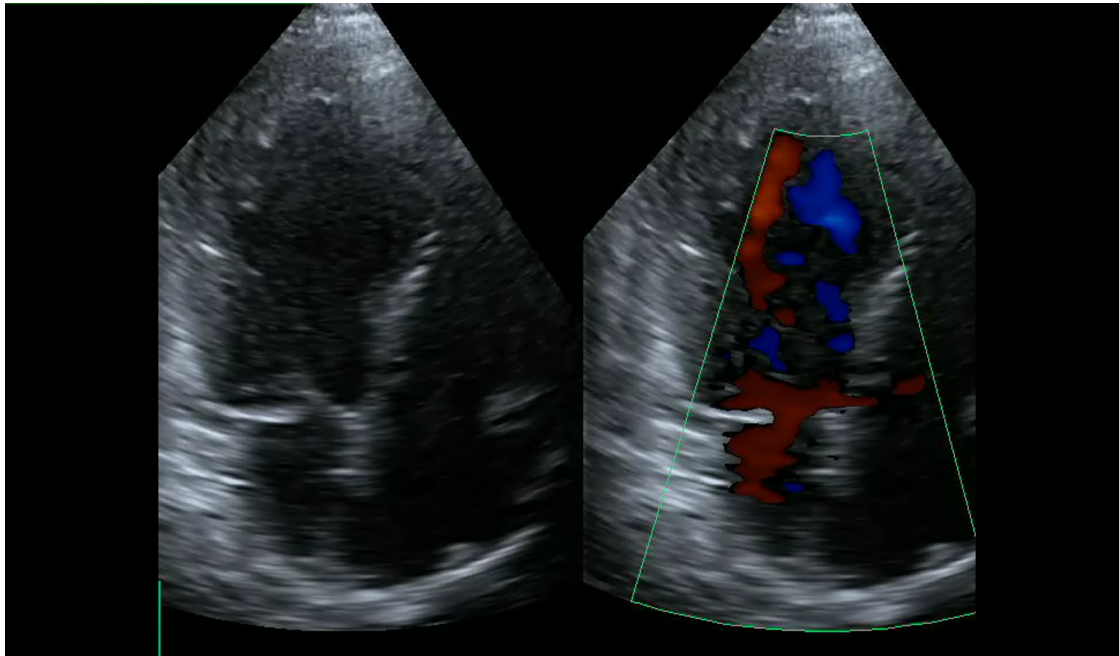
Baseline Measurement	Outcome During Conservative Management (n = 33)				Outcome After Surgery (n = 29)			
	Stable (n = 25)	Progression (n = 8)	OR (95% CI)	p Value	Good (n = 18)	Impaired (n = 11)	OR (95% CI)	p Value
Conventional echocardiography								
LVEF (%)	58.7 ± 5.4	57.6 ± 3.6	1.3 (0.6–3.0)	0.57	53.9 ± 9.8	45.2 ± 11.8	2.3 (1.1–6.1)	0.04
LVEDVI (ml/m ²)	58.9 ± 16.4	64.9 ± 21.1	1.4 (0.6–3.5)	0.39	92.2 ± 24.8	119.7 ± 33.4	3.0 (1.2–10.7)	0.01
LVESVI (ml/m ²)	24.2 ± 7.1	27.8 ± 10.2	1.6 (0.7–4.0)	0.26	43.6 ± 18.8	67.5 ± 27.7	3.2 (1.3–10.5)	0.01
Speckle tracking								
ε _{sys} (%)	-19.0 ± 2.6	-16.3 ± 3.3	3.2 (1.2–13.8)	0.02	-15.6 ± 2.3	-11.5 ± 4.3	3.7 (1.4–14.4)	0.006
SR _{sys} (s ⁻¹)	-1.19 ± 0.17	-1.04 ± 0.14	3.3 (1.2–13.4)	0.02	-1.01 ± 0.17	-0.88 ± 0.19	2.6 (1.0–9.0)	0.04
SR _{dia} (s ⁻¹)	1.60 ± 0.30	1.20 ± 0.34	4.6 (1.6–18.8)	0.002	1.33 ± 0.36	0.98 ± 0.21	4.0 (1.4–16.3)	0.005

Cut-off: -18%

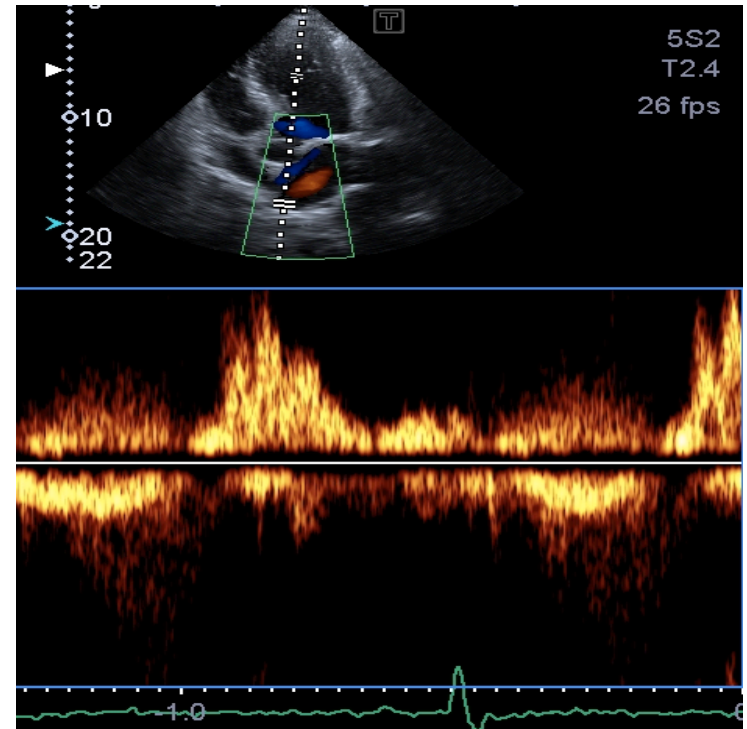
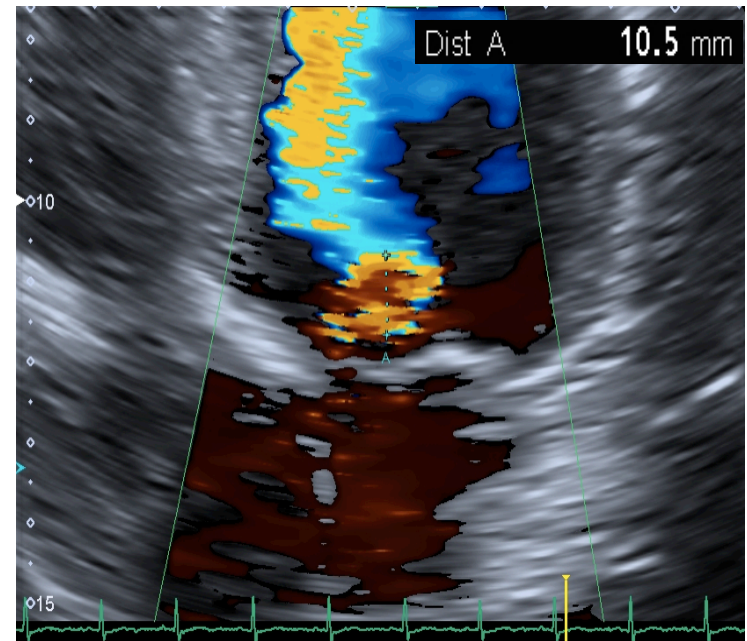
Cut-off: -14%

N. Olsen, JACC: Cardiovascular Imaging 2011

Insuffisance mitrale

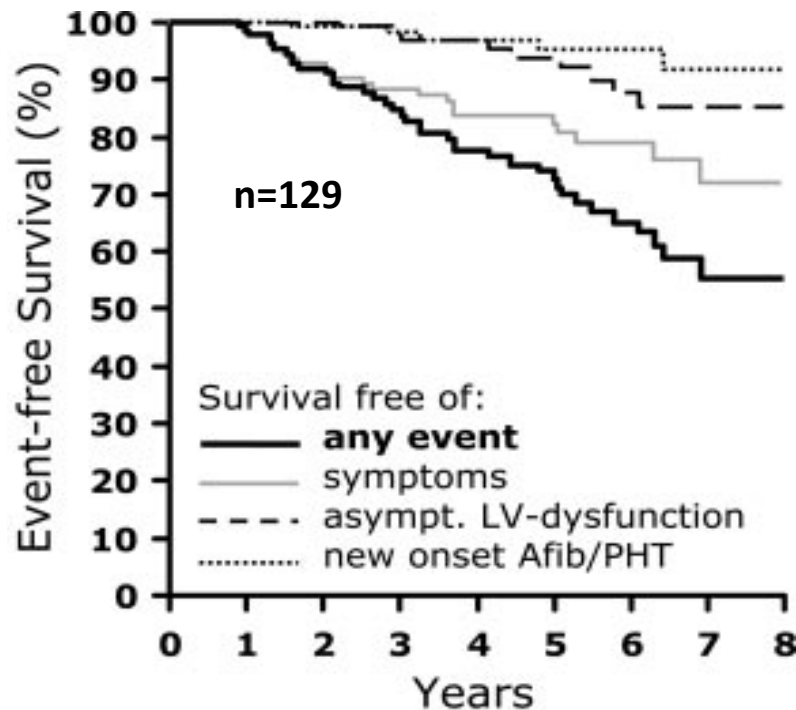


- Un homme de 55 ans
- Asymptomatique

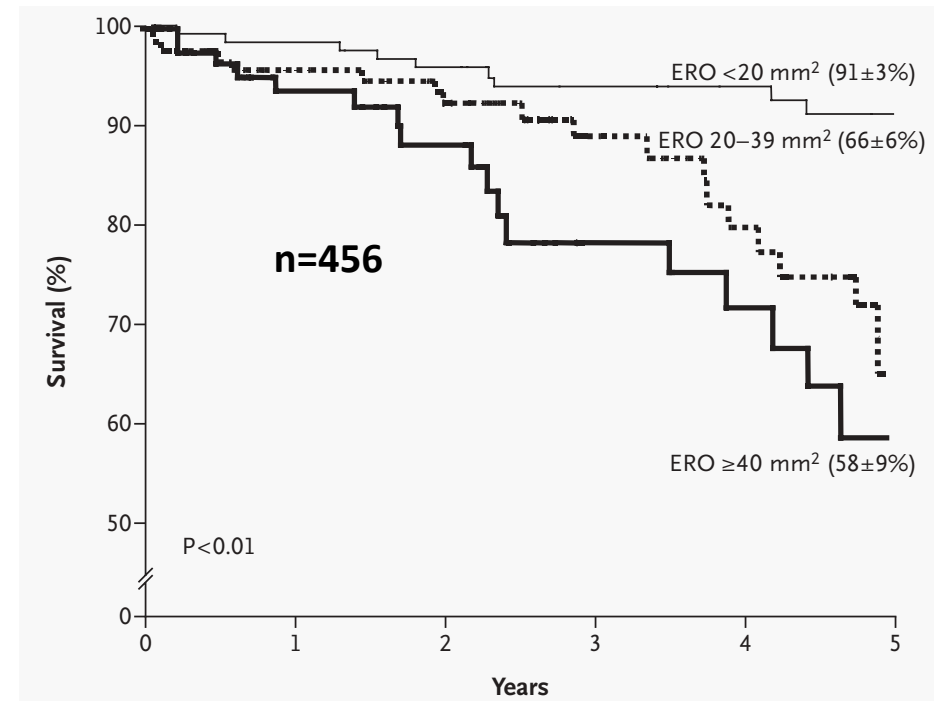


Insuffisance mitrale

- La survie est moins favorable chez les patients avec une IM sévère



R. Rosenhek, Circulation 2006



M. Enriquez-Sarano, N Eng J Med, 2005

- Développement des symptômes fait une indication plus fréquente pour l'intervention chirurgicale

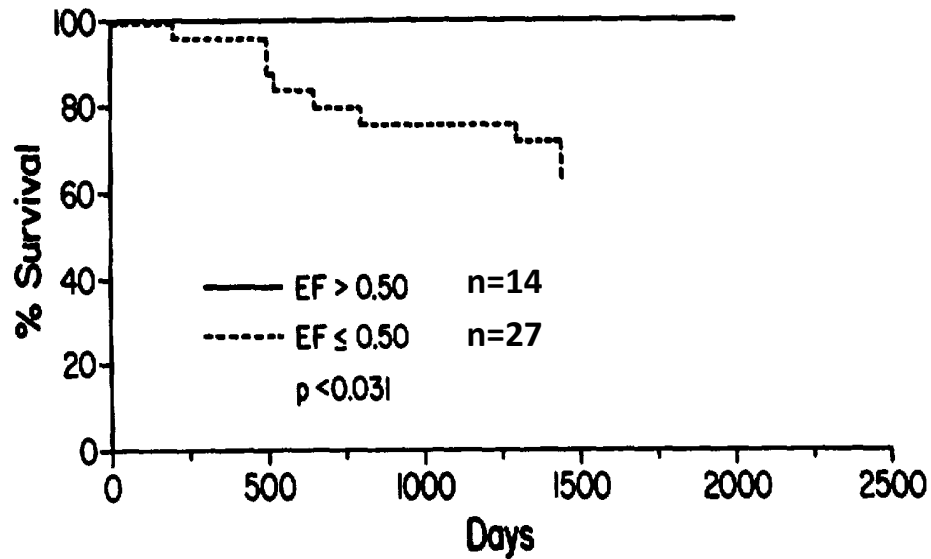
Insuffisance mitrale

Recommandation pour l'intervention chirurgicale

	Class ^a	Level ^b
Mitral valve repair should be the preferred technique when it is expected to be durable.	I	C
Surgery is indicated in symptomatic patients with LVEF >30% and LVESD <55 mm.	I	B
Surgery is indicated in asymptomatic patients with LV dysfunction (LVESD ≥45 mm and/or LVEF ≤60%).	I	C

*Guidelines on the management of the valvular heart disease
(version 2012) ESC and EACTS*

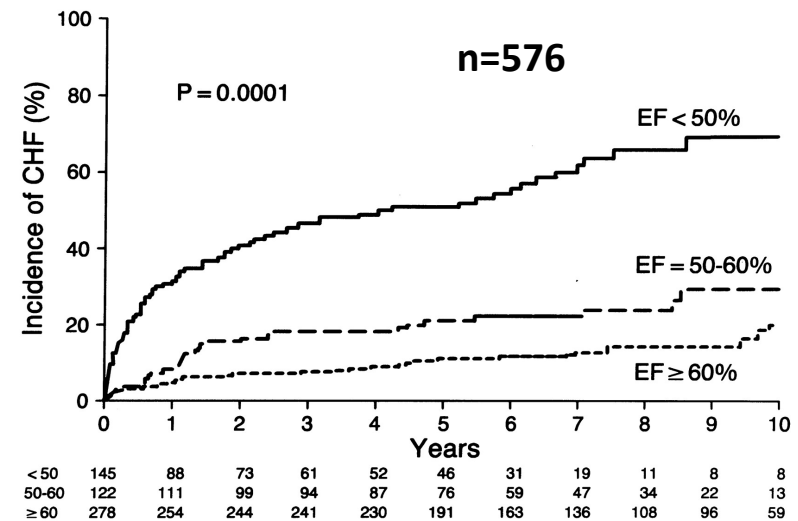
Insuffisance mitrale



M. Crawford, Circulation 1990

- La survie est moins favorable chez les patients avec FEVG préopératoire diminué

- L'incidence d'insuffisance cardiaque selon FEVG préopératoire



M. Enriquez-Sarano, Circulation 1995

Insuffisance mitrale

Postopératoire		FEVG≥50%		FEVG<50%	
e	Variable	Total	Group A (n = 73)	Group B (n = 15)	P
Left ventricle					
	LVEDD (mm)	36 ± 6.1	35.0 ± 5.8	40.6 ± 5.3	.001
	LVEDD index (mm/m²)	19.7 ± 3.6	19.2 ± 3.7	21.6 ± 2.6	.02
	LVEDD (mm)	52.3 ± 23.3	54.7 ± 7.8	61.5 ± 6.6	.002
	LVESV (mL)	55.9 ± 8	49.8 ± 23.0	64.5 ± 21.3	.02
	LVEDV (mL)	149.8 ± 52.2	143.9 ± 50.0	178.2 ± 33.4	.01
	E (transmitral pulsed Doppler) (cm/sec)	129.9	128 ± 32	127 ± 30	.48
	LV S' (tissue Doppler) (cm/sec)	9.3 ± 2.5	8.4 ± 3.7	9.5 ± 2.0	.25
	LVEF (%)	66 ± 7	66.2 ± 6.4	64.6 ± 10.1	.43
	LV GLS (%)	−19.1 ± 3.6	−19.6 ± 3.6	−17.0 ± 2.8	.01
	LV GLS/LVEDD (%/mm)	−5.4 ± 1.4	−5.7 ± 1.3	−4.3 ± 1.1	.001

S. Mascle, J Am Soc Echocardiography 2012

- Strain longitudinal est plus bas même si FEVG préopératoire est normale
- Valeur prédictive de FEVG postopératoire < 50%

Prédiction de FEVG < 50%

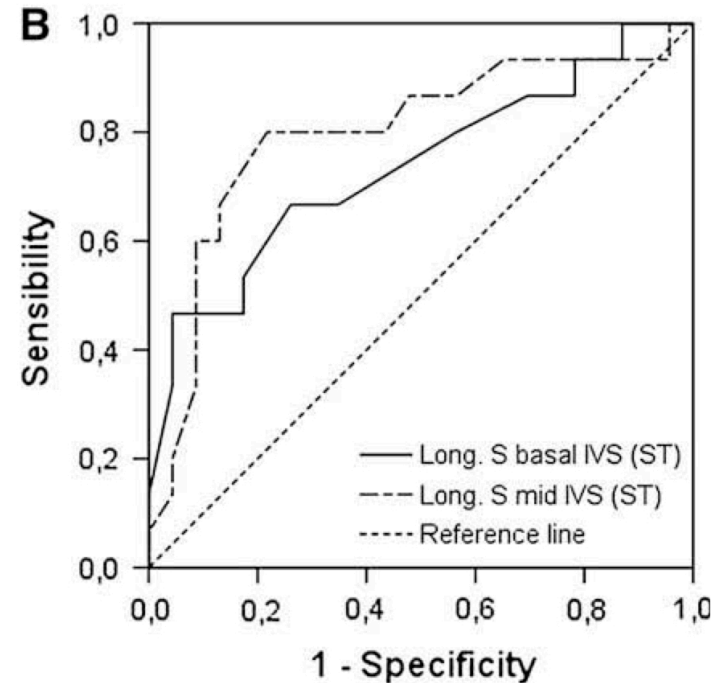
Parameter	Threshold value	Area under the curve	Sensitivity	Specificity
LA volume (mL/m ²)	60	0.66	60%	78%
LVEDD (mm/m ²)	22	0.71	53%	78%
sPAP (mm Hg)	50	0.65	27%	93%
LV GLS (%)	-18	0.76	53%	79%

S. Mascle, J Am Soc Echocardiography 2012

Insuffisance mitrale

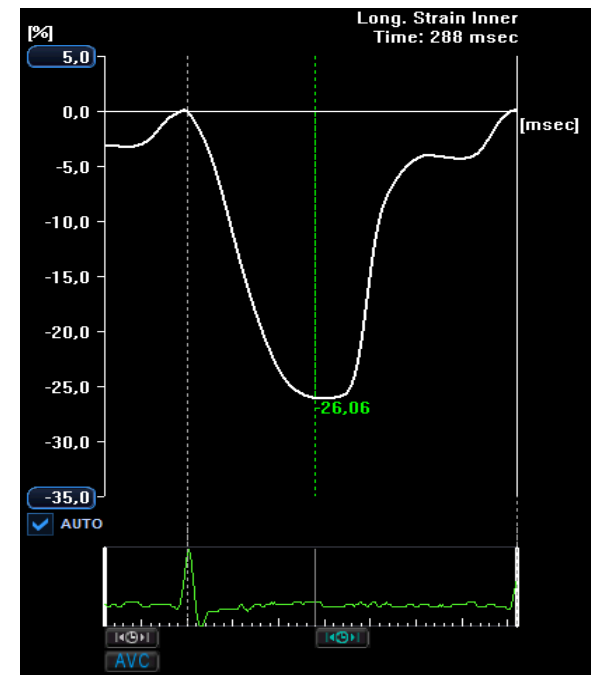
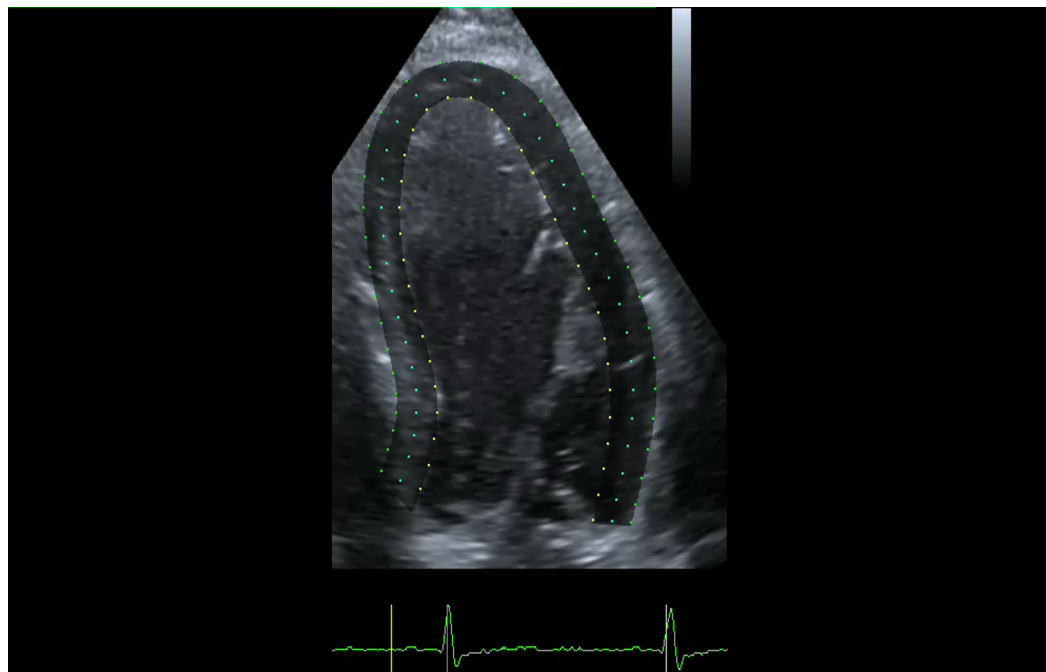
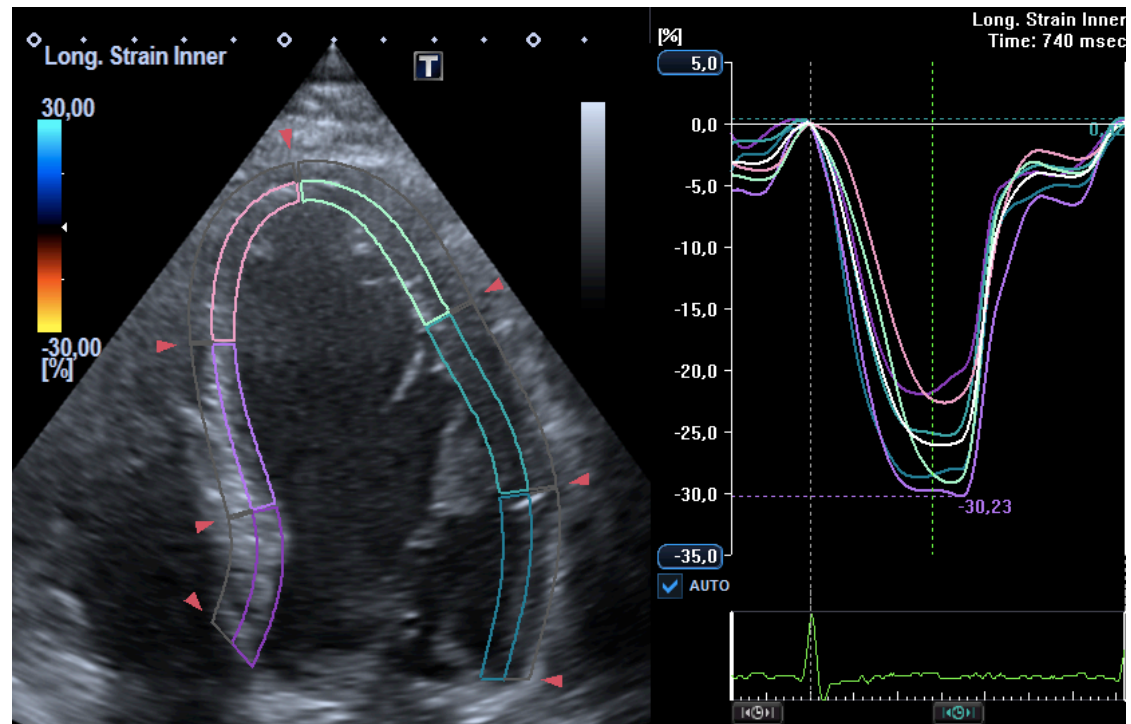
Variable	Group 1 (postoperative LVEF decrease < 10%)	Group 2 (postoperative LVEF decrease > 10%)	P
n	23 (60.5%)	15 (39.4%)	
Mean age (y)	62.9 ± 10.8	57.0 ± 10.4	.1
Men (%)	8 (34.8%)	6 (40%)	.74
LA diameter (cm)	5.4 ± 0.8	5.7 ± 1.8	.41
IVS (cm)	1.1 ± 0.18	1.0 ± 0.26	.66
Posterior wall (cm)	0.97 ± 0.16	0.97 ± 0.24	.97
EDV (3D) (mL)	87.6 ± 35.4	122.8 ± 55.9	.023
ESV (3D) (mL)	32.5 ± 15.2	48.3 ± 28.2	.032
LVEF (3D)	62.5 ± 7.9	61.7 ± 9	.77
ERO (cm ²)	0.38 ± 0.15	0.53 ± 0.33	.06

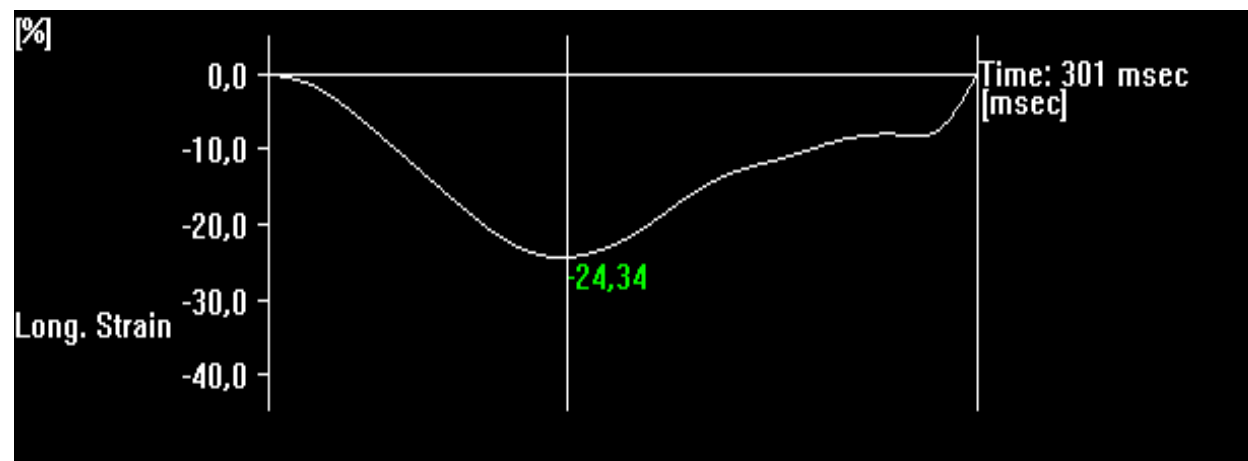
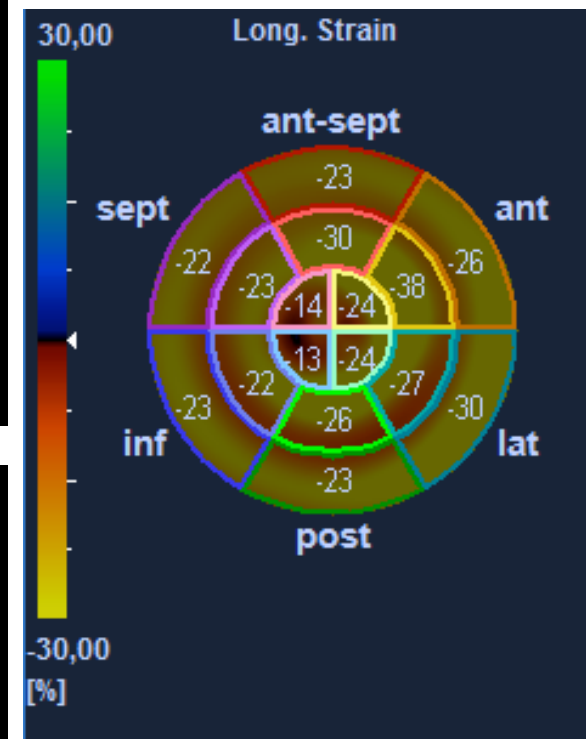
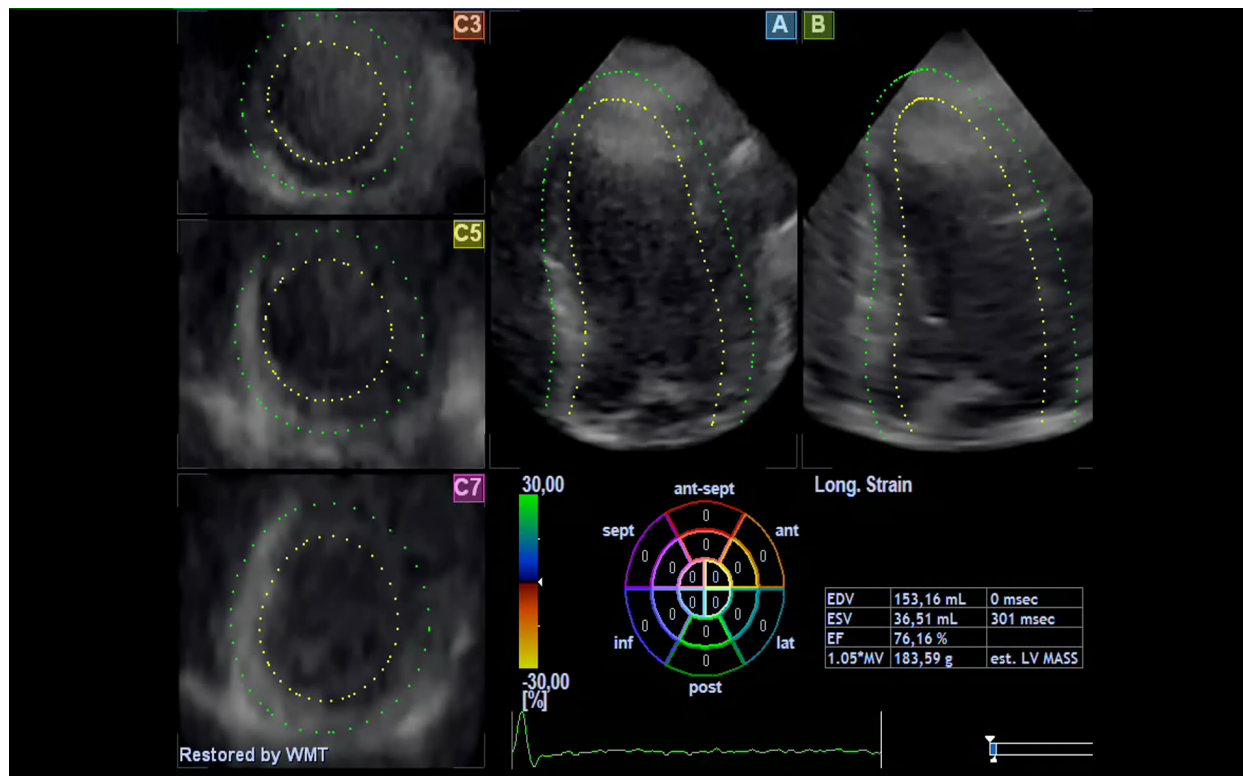
Variable	Group 1 (postoperative LVEF decrease < 10%) (n = 23)	Group 2 (postoperative LVEF decrease > 10%) (n = 15)	P
Speckle tracking			
Longitudinal S, basal IVS	-0.17 ± 0.04	-0.13 ± 0.04	.006
Longitudinal SR, basal IVS	-1.2 ± 0.03	-0.76 ± 0.03	<.001
Radial S, basal IVS	0.17 ± 0.14	0.10 ± 0.11	.12
Radial SR, basal IVS	1.5 ± 0.85	1.2 ± 0.54	.35
Longitudinal S, mid IVS	-0.19 ± 0.05	-0.14 ± 0.05	.006
Longitudinal SR, mid IVS	-1.12 ± 0.21	-0.81 ± 0.20	<.001
Radial S, mid IVS	0.16 ± 0.18	0.19 ± 0.13	.67
Radial SR, mid IVS	1.5 ± 0.94	1.42 ± 0.80	.59



- Strain longitudinal plus bas chez les patients qui baissent son FEVG > 10%
- Valeur prédictive sur la dysfonction VG postopératoire

L. Perez de Isla, J Am Soc Echocardi, 2009





Conclusions

- Paramètres de la déformation peuvent être diminués chez les patients avec cardiomyopathies ischémiques et valvulaires même si FEVG est normale
- Paramètres du strain sont plus sensibles et pourraient être les précurseurs de la chute de FEVG
- SLG a une valeur supplémentaire en prédiction du pronostic moins favorable chez les patients avec une cardiomyopathie ischémique comme chez les patients avec une insuffisance aortique ou mitrale

Take home message

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

Currently, 3D TTE and TEE assessment of LV volumes and ejection fraction is recommended over the use of 2D echocardiography, as it has been clearly demonstrated to provide more accurate and reproducible measurements.

R Lang, J Am Soc Echocardiogr 2012;25;3-46

Les volumes et FEVG en 3D si possible

ASE/EAE Consensus Statement on Methodology and Indications: Current and Evolving Echocardiographic Techniques for the Quantitative Evaluation of Cardiac Mechanics

3D STE promises to allow accurate assessment of regional ventricular dynamics. Nevertheless, it still requires rigorous validation and testing.

V Mor-Avi, J Am Soc Echocardiogr 2011;24:277-313

Pour instant le strain longitudinal en 2D est plus validé et disponible

Mais il n'est pas encore inclus dans les recommandations

