HFPEF: comment diagnostiquer
L'échographie d'effort

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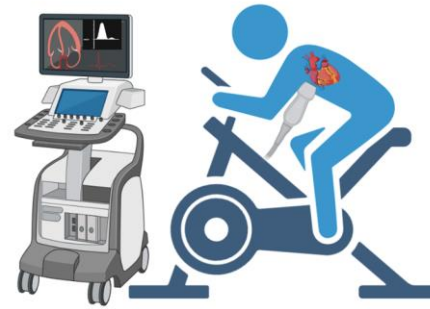


Conflits d’intérêts

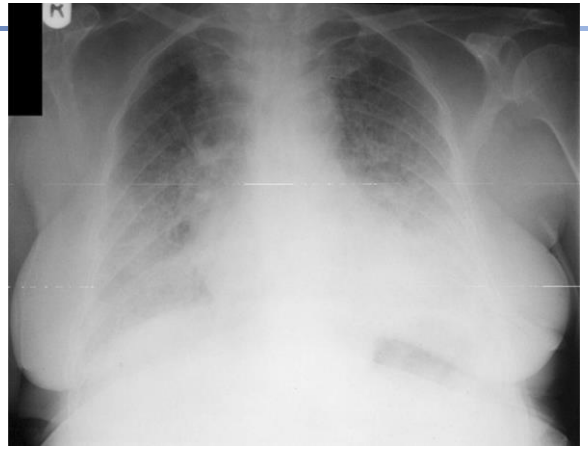
Honoraires ou une participation aux frais relatifs à la participation à des réunions scientifiques de la part: d’Abbott Medical, Bayer, MSD, Occlutech, Boehringer Ingelheim et Novartis.

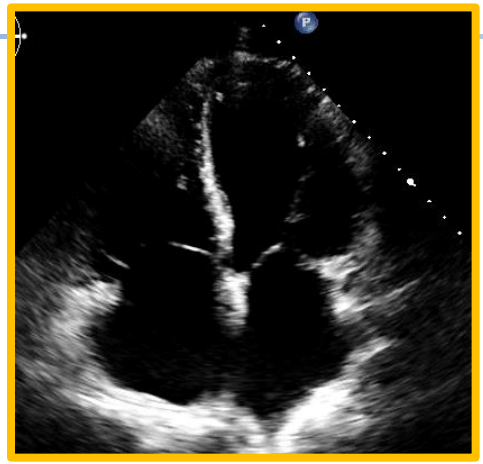
76 years old women
-chronic hypertension
-Type 2 Diabetes Mellitus
-BMI = 34 kg/m²

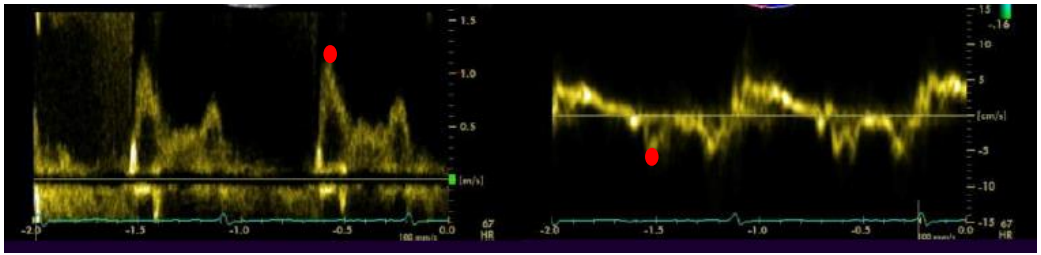
Acute pulmonary edema

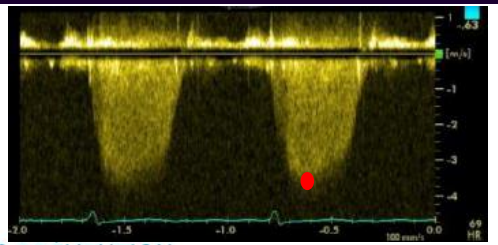
Echo
-preserved LVEF = 75%
-LV concentric remodeling (RWT=0.48)
-enlarged LA
-E/e' ratio= 20
-Peak TRV= 3.5 m/s

NT-proBNP = 1300 pg/mL (SR)



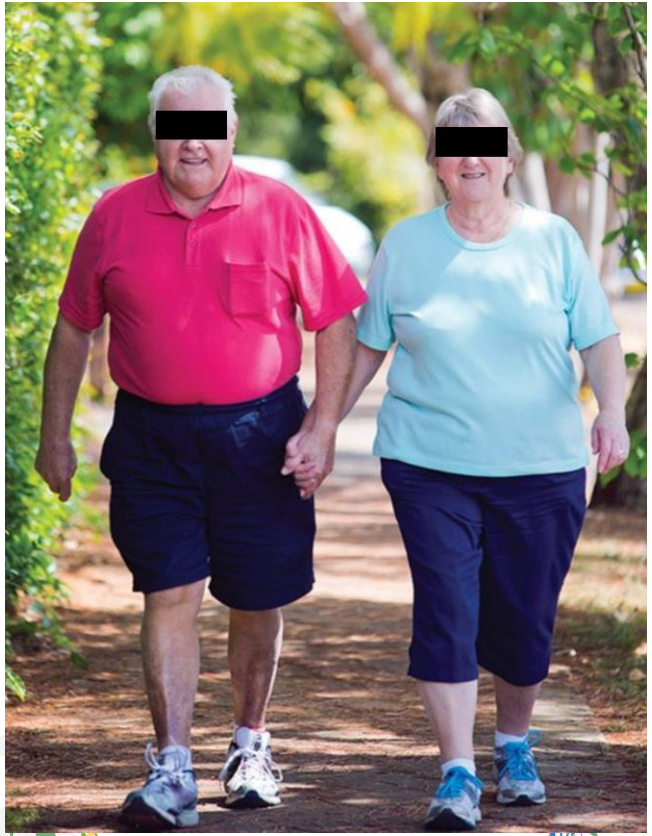




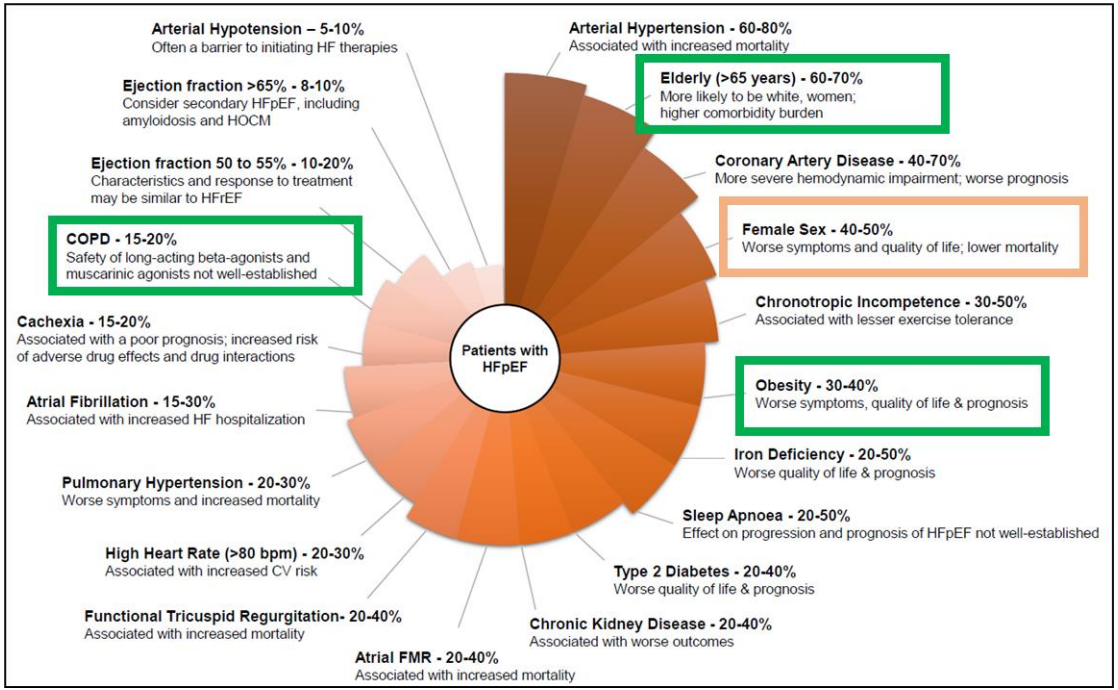


Many patients are at an “early” non congestive stage:

Dyspnea / exercise intolerance



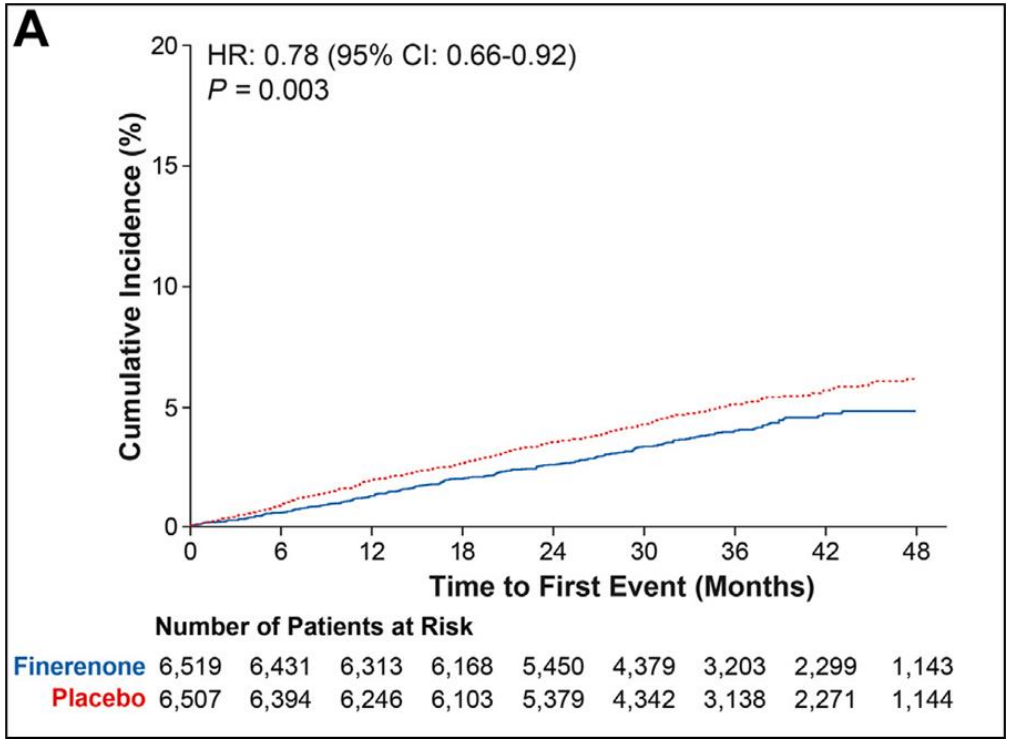
Comorbidities



Finerenone and Heart Failure Outcomes in Chronic Kidney Disease and Diabetes

- n=13026 patients
- T2D and CKD
- Under ACE or ARB (99.8%)

- History of HF ≈8%
- CAD ≈30%



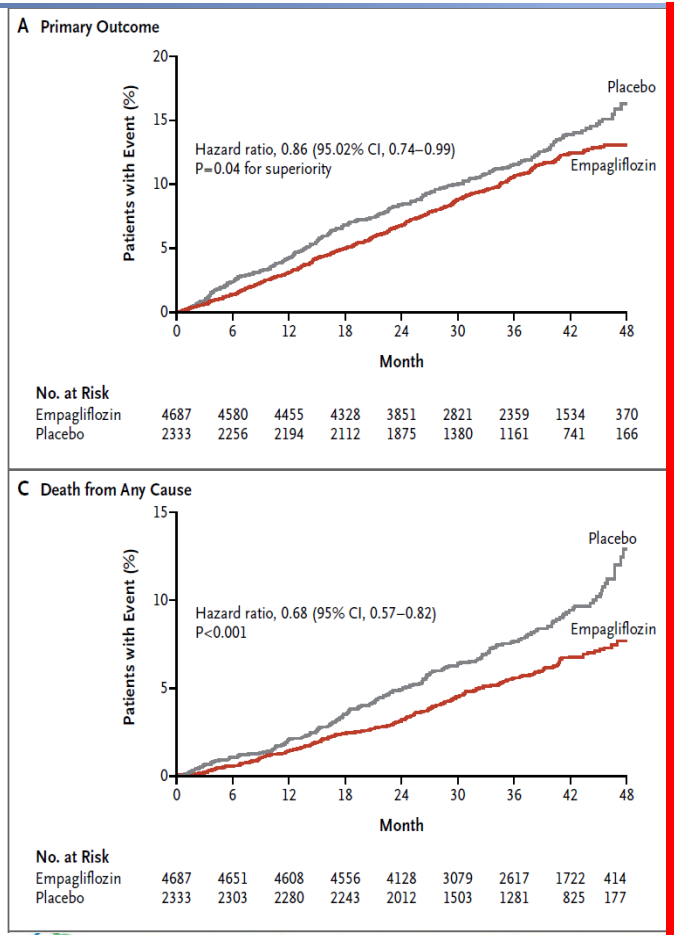
Time to first Hospitalization for HF

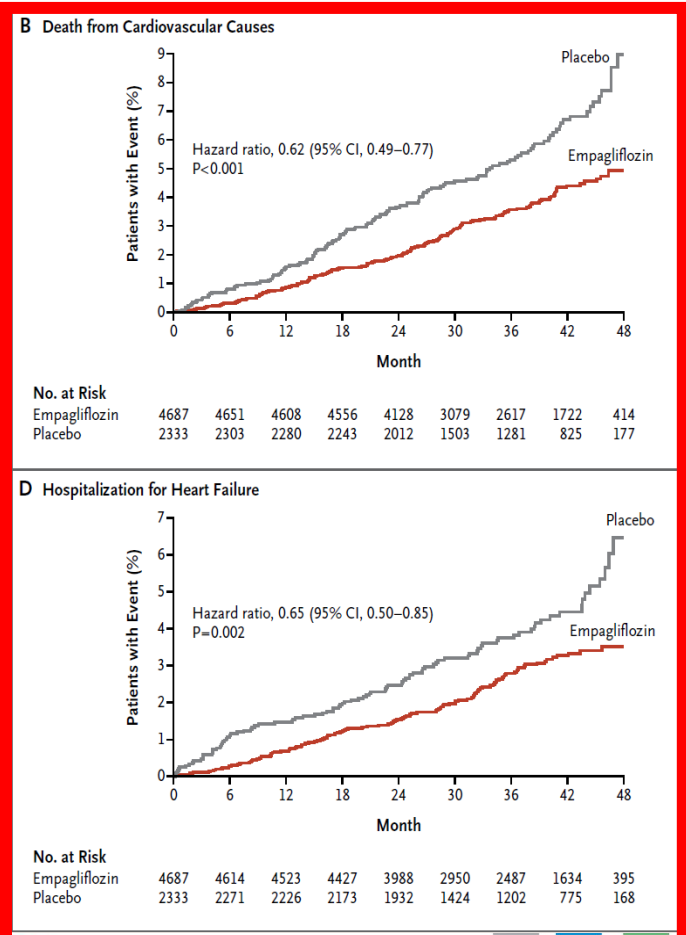
Filippatos G, et al. J Am Coll Cardiol HF. 2022;10(11):860-870.

Empagliflozin, Cardiovascular Outcomes, and Mortality in Type 2 Diabetes

n=7020 patients
T2D at high CV risk
History of HF ≈10%
CAD ≈75%

Primary composite outcome:
-death from CV causes,
-myocardial infarction,
-stroke





Zinman et al, nejm 2015

Invasive exercise hemodynamics: Gold standard

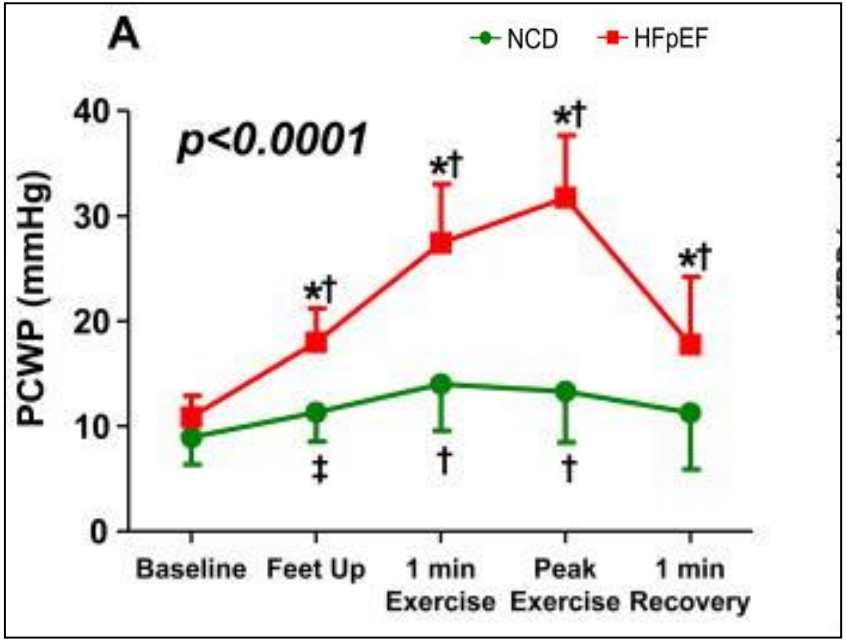
N=55 patients with dyspnea

-TTE: normal (LVEF >50%)

-BNP level: normal

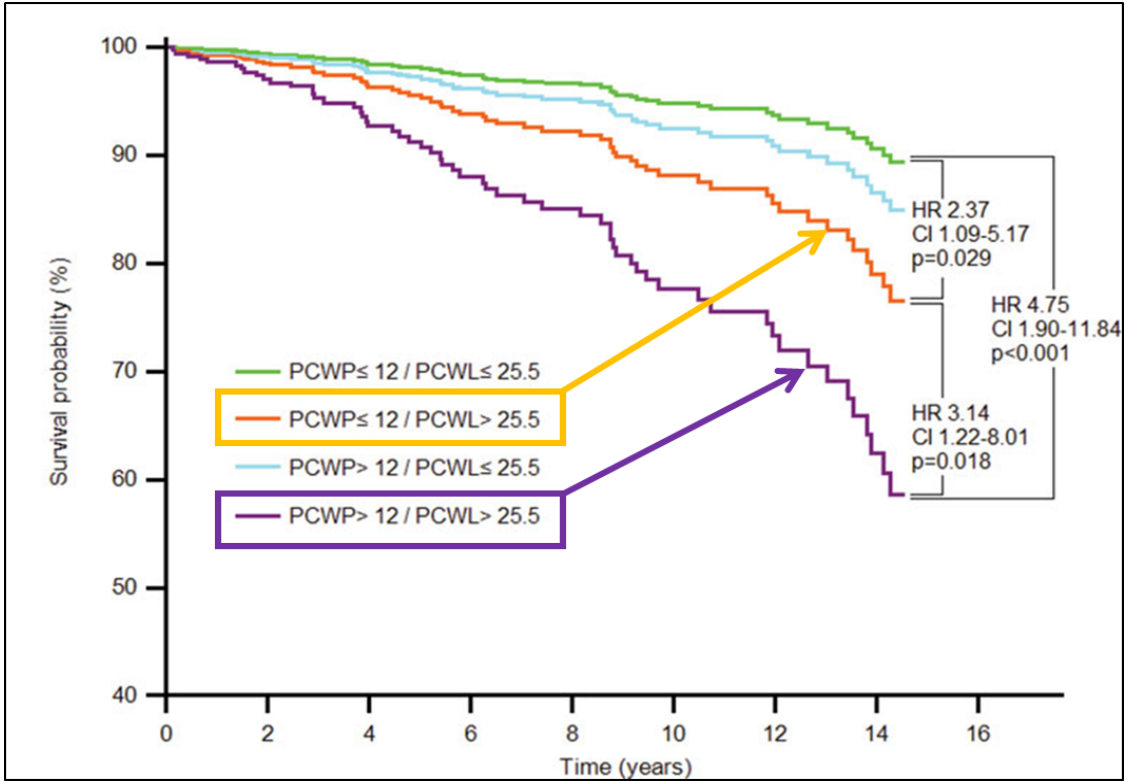
-RHC: normal PCWP at rest

>> 32 (58%) abnormal exercise PCWP ≥ 25mmHg



Borlaug et al, Circ Heart Fail 2010

Abnormal exercise PCWP: linked to prognosis



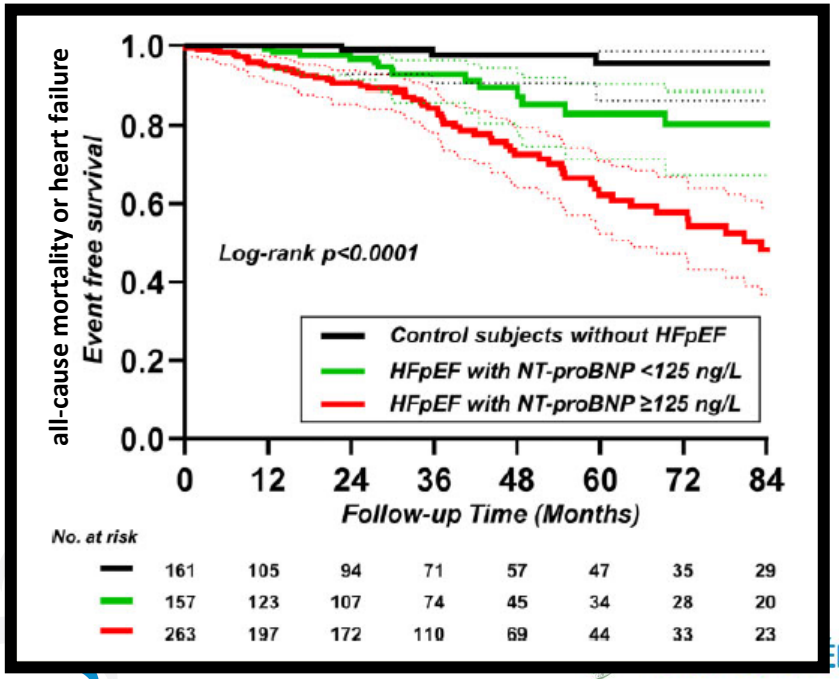
Early stage HFpEF: <u>PAWP ≤12 mmHg (rest) and ≥25 mmHg (exercise)</u>
-could be unmasked at low exercise level
-is associated with mortality

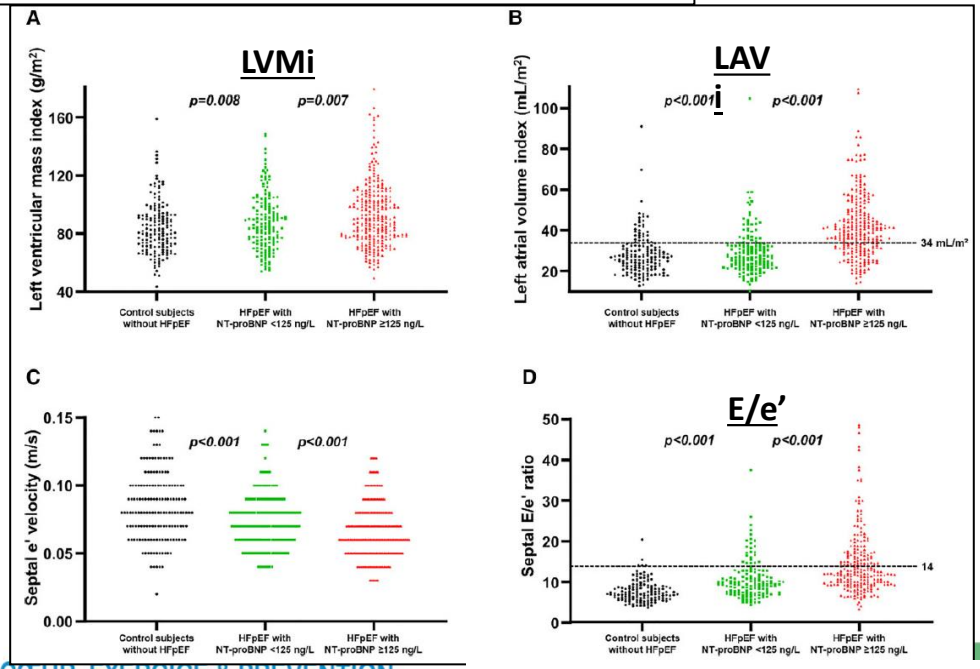
Dorfs et al, European Heart Journal 2014

Early stage HFPEF: resting echo and BNP not enough

Control subjects without HFpEF (n = 161)	HFpEF with NT-proBNP <125 ng/L (n = 157) ≈ 40%	HFpEF with NT-proBNP ≥125 ng/L (n = 263) ≈ 60%
NT-proBNP (ng/L) 73 (30–144)	65 (37–109)	790 (350–1506)

- HT >95%
- Diabetes ≈30%
- CAD ≈30%





Verbrugge et al, EHJ 2022

Table 4. Classification of HF by LVEF

Type of HF According to LVEF	Criteria
HFrEF (HF with reduced EF)	LVEF ≤40%
HFimpEF (HF with improved EF)	Previous LVEF ≤40% and a follow-up measurement of LVEF >40%
HFmrEF (HF with mildly reduced EF)	LVEF 41%–49% Evidence of spontaneous or provokable increased LV filling pressures (eg, elevated natriuretic peptide, noninvasive and invasive hemodynamic measurement)
HFpEF (HF with preserved EF)	LVEF ≥50% Evidence of spontaneous or provokable increased LV filling pressures (eg, elevated natriuretic peptide, noninvasive and invasive hemodynamic measurement)

Multimodality imaging in patients with heart failure and preserved ejection fraction: an expert consensus document of the European Association of Cardiovascular Imaging

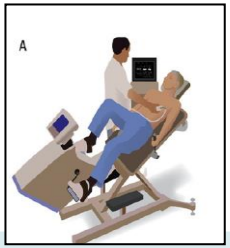


Table 4 Diastolic stress test: Indications and criteria for response

Diastolic stress test

Do not need the diastolic stress test:

- Preserved e′ at rest: mitral annulus septal e′ >7 cm/s and lateral e′ >10 cm/s. Unlikely to develop elevated LV filling pressures with exercise.
- Elevated LV filling pressure at rest, by echocardiography.

Candidates for the test:

- Grade 1 LV diastolic dysfunction with normal LV filling pressure at rest and signs of delayed myocardial relaxation.

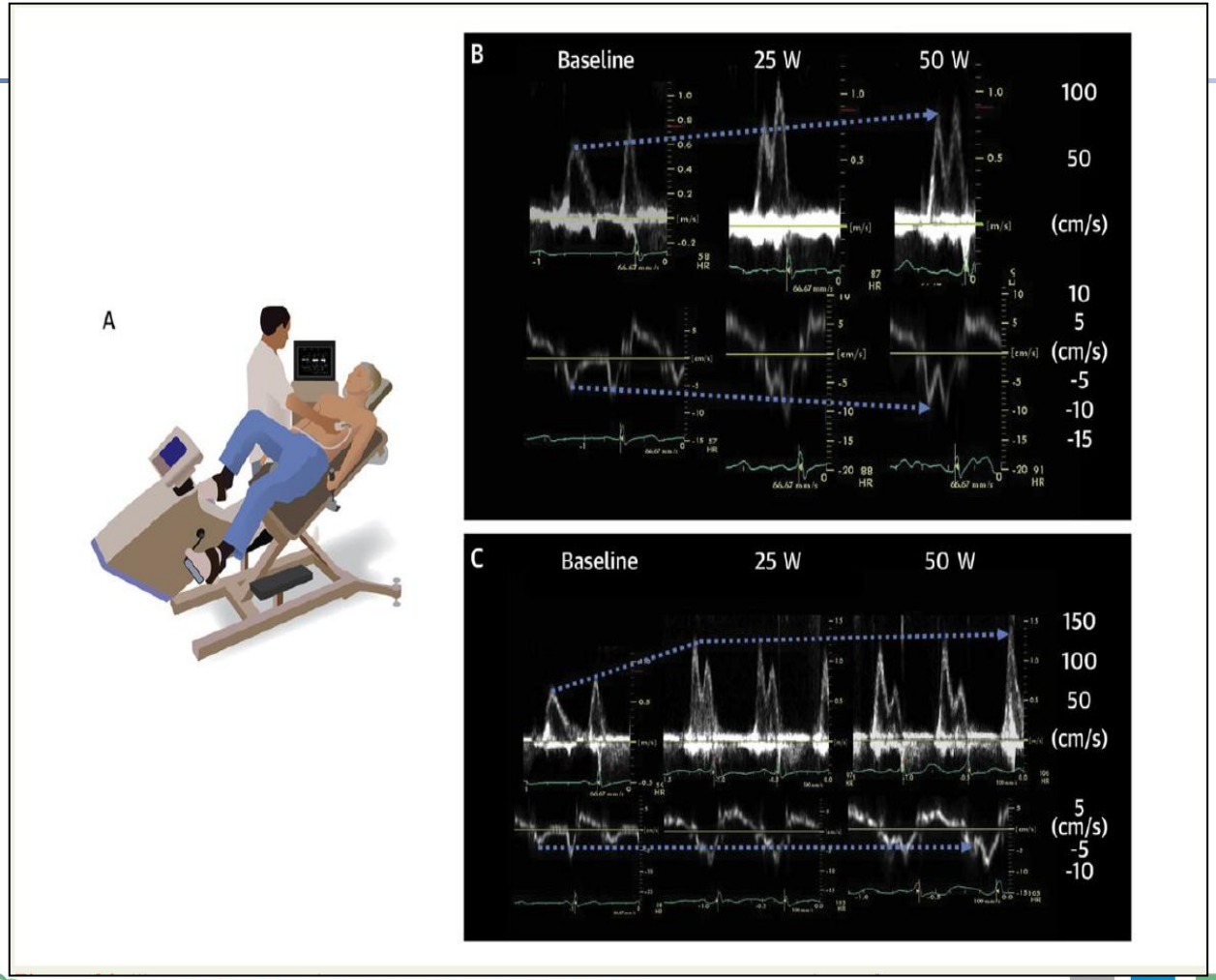
Diastolic stress test is positive when all of the following three conditions are met:

- Average *E*/e′ > 14 or septal *E*/e′ ratio >15 with exercise.
- Peak TR velocity >2.8 m/s with exercise.
- Septal e′ < 7 cm/s or if only lateral velocity is acquired, lateral e′ < 10 cm/s at baseline.

Normal response to diastolic stress test if both of the following two conditions are met:

- Average or septal *E*/e′ < 10 with exercise.
- Peak TR velocity <2.8 m/s with exercise.

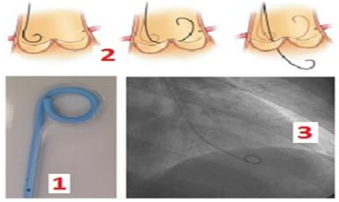
Exercise E/e’ ratio

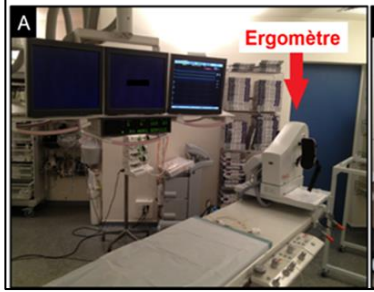


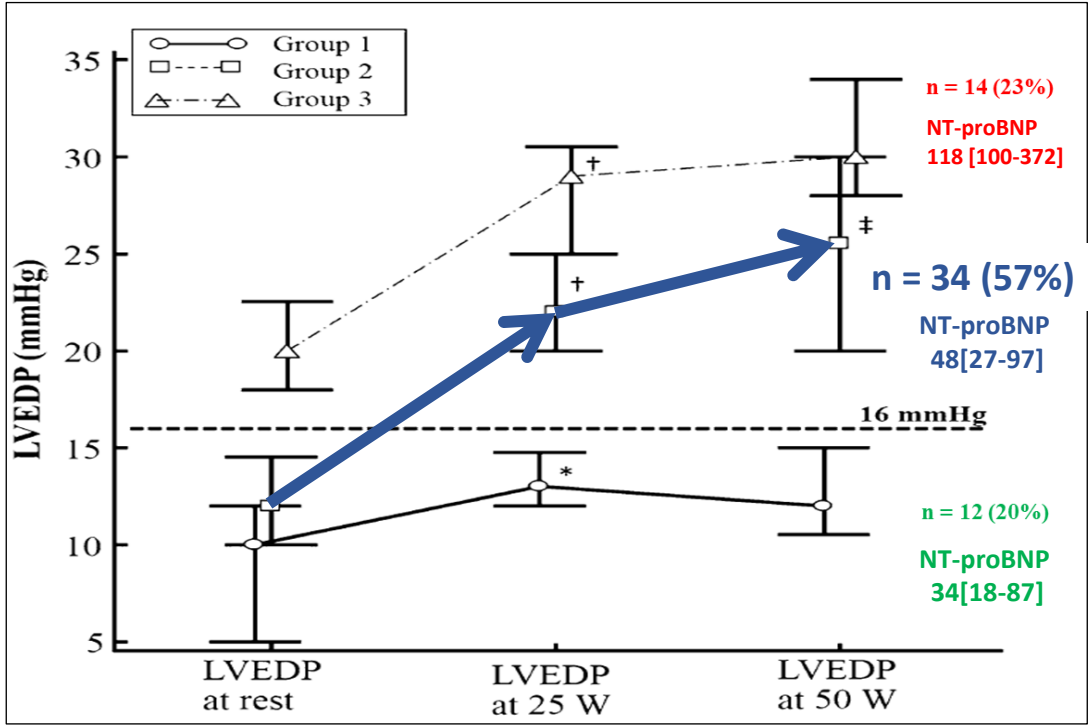
Average *E/e’* > 14 or septal *E/e’* ratio >15 with exercise.

European Heart Journal - Cardiovascular Imaging 2022

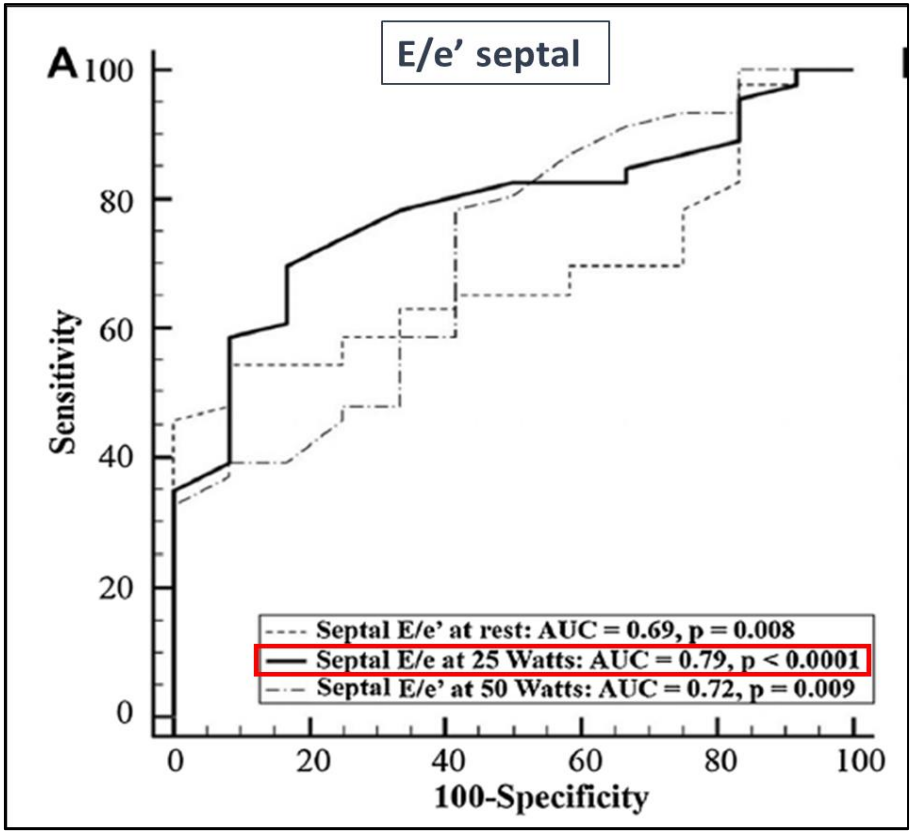
Variables	All patients ($n = 60$)
Demographics	
Age (years)	63.5 [54.6–70.3]
Male gender	46 (77)
Body mass index, kg/m^2	26.4 [23.9–28.5]
Prior PCI	14 (23)
Coronary stenosis >50 %	13 (22)
Hypertension	38 (63)
Diabetes	16 (27)
Smoking history	31 (52)

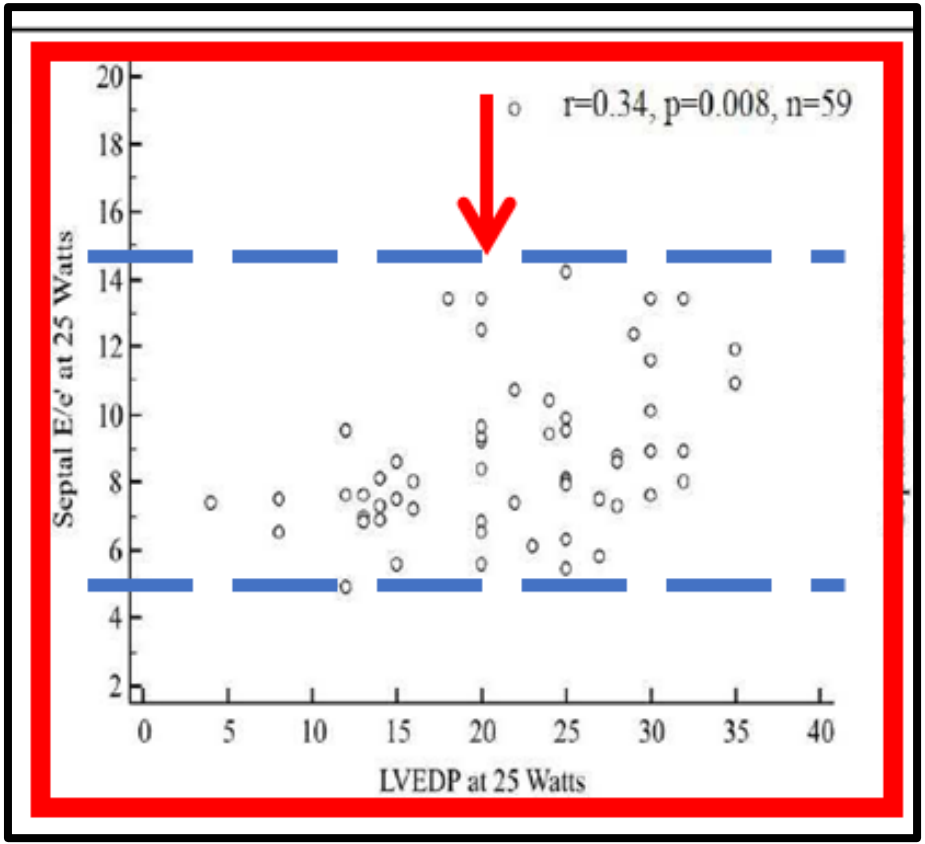




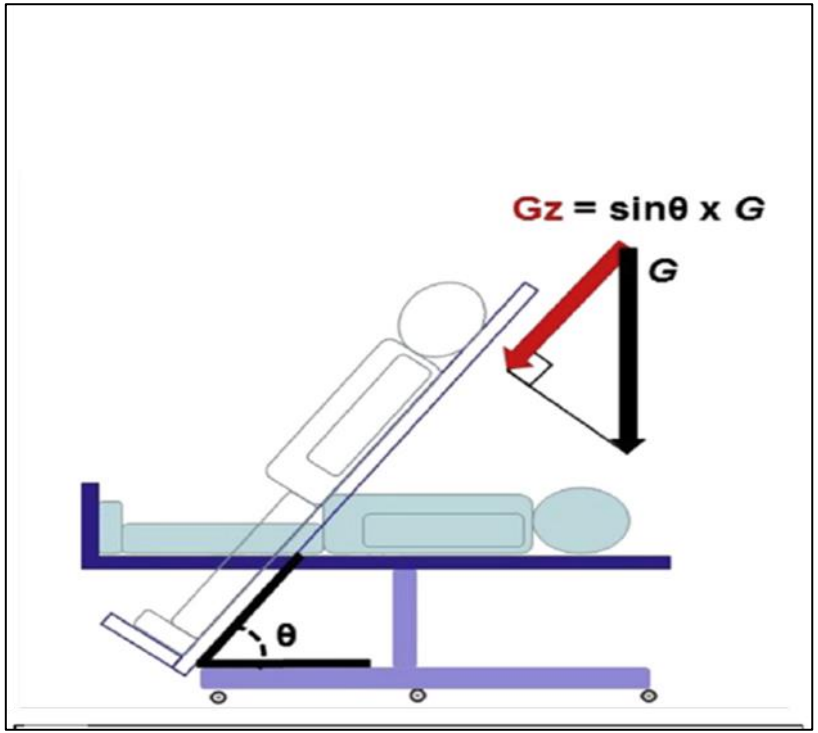


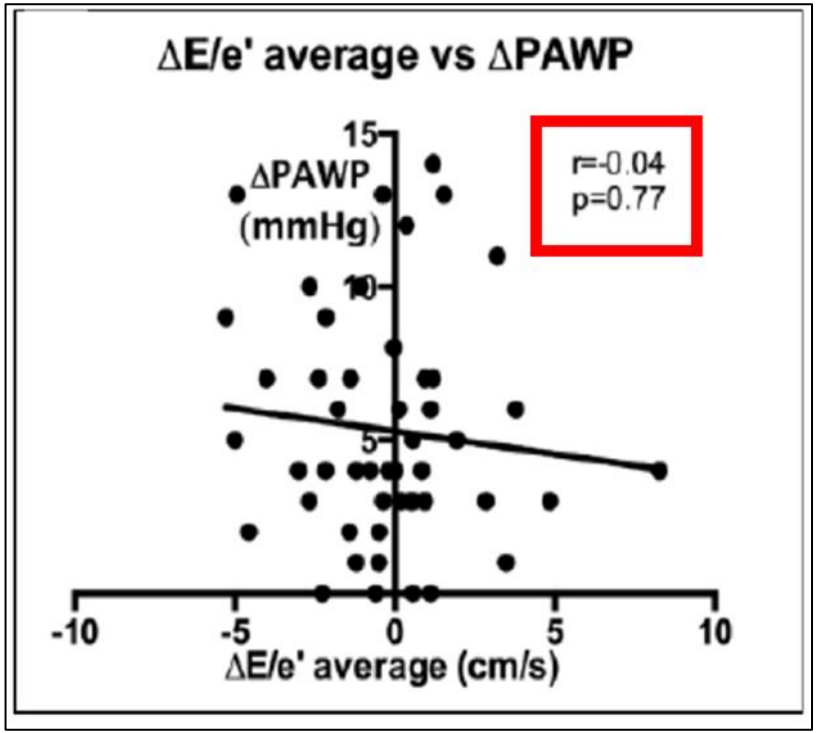
Hammoudi et al, Clin Res Cardiol 2017





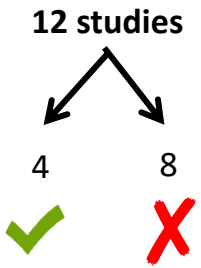
Hammoudi et al, Clin Res Cardiol 2017





Santos et al, Circ Heart Fail 2015

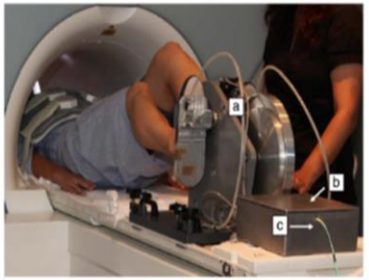
Exercise E/e' ratio to diagnose early stage HFpEF

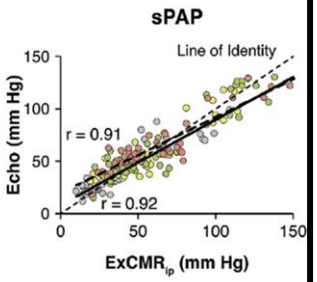


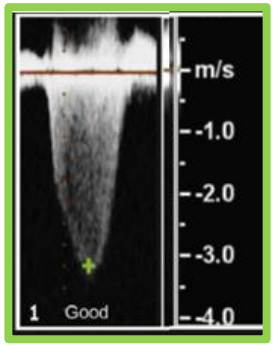
Etude	Design	Population	N	Intervention	Temporalité ETT/KT	E/e'	Mesure PRVG	Coefficient de corrélation (r) post intervention (PI) ou variation avant/après (Δ)	Commentaire
Intervention pour augmenter les pressions de remplissage VG									
Talreja, 2007	Prospective	Dyspnée d'effort (NYHA II-III)	12	Cyclo-ergomètre semi-couché	Simultanée	Septal	Pcap	NA	**E/e' > 15 prédit une Pcap ≥ 20mmHg Se = 83%, Sp = 100%**
Maeder, 2010	Cas-témoin	14 ICFEP et 8 contrôles	22	Cyclo-ergomètre semi-couché	Simultanée	Septal	Pcap	r = 0,22 (p = 0,33) (PI)	
Choi, 2016	Prospective	ICFEP	181	Lever de jambe	Simultanée	Septal	PTDVG	NA	↑ PTDVG, ↔ E/e'_{septal}
Hammoudi, 2017	Prospective	FEVG > 50% + coronarographie	60	Cyclo-ergomètre couché	Consécutive	Septal	Pcap	**25W: r=0,34 (*p* = 0,008) (PI) 50W: r = 0,34 (*p = 0,01*) (PI)**	
Obokata, 2017	Prospective	50 ICFEP + 24 dyspnée inexpliquée	74	Cyclo-ergomètre couché	Simultanée	Moyen	Pcap	**r = 0,57 (*p* < 0,0001) (PI)**	
Chen, 2019	Prospective	ICFEP	34	Cyclo-ergomètre couché	Simultanée	Septal, latéral, moyen	Pcap	Stress E/e' vs ΔPcap : **Septal : r = 0,68 (*p < 0,001*) Latéral : r = 0,55 (*p = 0,001*) Moyen : r = 0,62 (*p < 0,001*)**	
Intervention pour diminuer les pressions de remplissage VG									
Efstratiadis, 2009	Prospective	ICFEP	10	Nesiritide IV	Consécutive	Latéral	PTDVG & Pcap	NA	↓ PTDVG & Pcap & E/e' latéral Pas de corrélation entre ΔE/e' et PTDVG
Chan, 2011	Prospective	Patients sans coronaropathie	16	Dobutamine IV	Simultanée	Septal, latéral	PTDVG	Septal : r = 0,61 (*p* = 0,46) (PI) Latéral : r = 0,78 (*p* = 0,27) (PI)	
Manouras, 2013	Prospective	Angor stable et/ou dyspnée d'effort	38	Nitroglycérine IV	Simultanée	Septal, latéral, moyen	PTDVG	r = 0,08 (NS) (Δ)	
Santos, 2015	Prospective	Dyspnée inexpliquée	118	Semi-couchée vers debout	Simultanée	Septal, latéral, moyen	Pcap	ΔE/e' vs ΔPcap Septal : r = 0,07 (*p* = 0,61) Latéral : r = -0,07 (*p* = 0,61) Moyen : r = -0,04 (*p* = 0,77)	
Intervention pour augmenter et diminuer les pressions de remplissage VG									
Firstenberg, 2000	Prospective	Volontaires sains	7	Perfusion saline (↑) et inclinaison négative (↓)	Simultanée	Septal, latéral	Pcap	Septal : r = 0,14 (NS) (PI) Latéral : r = 0,17 (NS) (PI)	
Bhella, 2011	Prospective	11 ICFEP et 36 contrôles	47	Perfusion saline (↑) et inclinaison négative (↓)	Simultanée	Moyen	Pcap	Coefficient de détermination individuel R^2 varie de 0,00 à 0,94	E/e'_{moyen} ne donne pas une estimation fiable des variations la Pcap

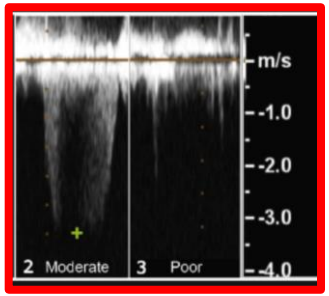
Sharifov et al. JAHA 2017
Hammoudi et al. 2017
Obokata et al. 2017
Chen et al 2019

Exercise TRV ratio to track systolic PAP









	N	Echo	Cath	Bias	SD of Bias	Limits of Agreement	r	*P* Value
PASP at peak								
Overall	65	40.4±15.6	42.3±19.0	1.9	16.3	−30.1 to 33.9	0.57	<0.001
A	22	48.8±19.6	46.9±23.5	−1.9	15.6	−32.3 to 28.6	0.75	<0.001
B	28	38.2±12.0	41.2±15.6	3.0	15.1	−26.7 to 32.6	0.42	0.03
C	15	32.1±8.5	37.5±17.0	5.4	19.3	−32.5 to 43.3	-0.05	0.87

Feasible in only ≈ 30% of cases

Claessen et al, JACC img 2015; Van Riel et al. *Circ Crdiovasc Imaging*. 2017; *Amsallem et al, J Am Soc Echocardiogr 2016;29:93-102*

Normal subjects

	All ($n = 70$)	Age 20-30 ($n = 13$)	Age 30-40 ($n = 10$)	Age 40-50 ($n = 14$)	Age 50-60 ($n = 12$)	Age 60-70 ($n = 11$)	Age 70-80 ($n = 10$)
PASP at rest (mmHg)	27 ± 4	27 ± 4	29 ± 3	28 ± 3	26 ± 4	27 ± 4	28 ± 6
PASP at first workload step (mmHg)	34 ± 6	31 ± 4	33 ± 5	34 ± 4	31 ± 6	37 ± 9	37 ± 5
PASP at peak exercise (mmHg)	51 ± 9	45 ± 7	51 ± 6	52 ± 9	53 ± 4	54 ± 12*	58 ± 7*
Increase in PASP (mmHg)	27 ± 8	22 ± 8	24 ± 7	27 ± 10	29 ± 5	29 ± 9	30 ± 8

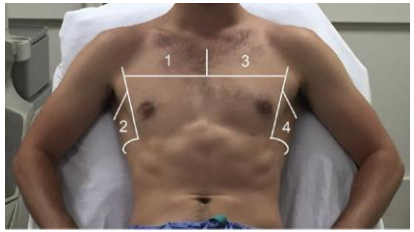
*No significant differences between strata except for PASP at peak exercise: $P = 0.01$.

-peak sPAP**≥ 60mmHg (3.5m/s) : 36% 60-70 years, 50% >70years**

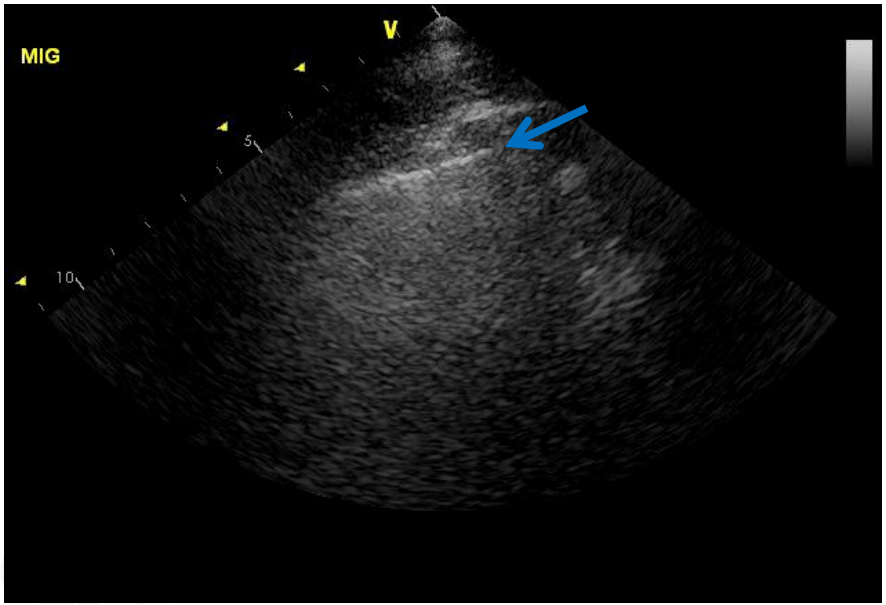
- sPAP > 3.5m/s at 25 Watts: not observed in normal subjects

Mahjoub et al. Eur J Echocardiography 2009 (Amiens)

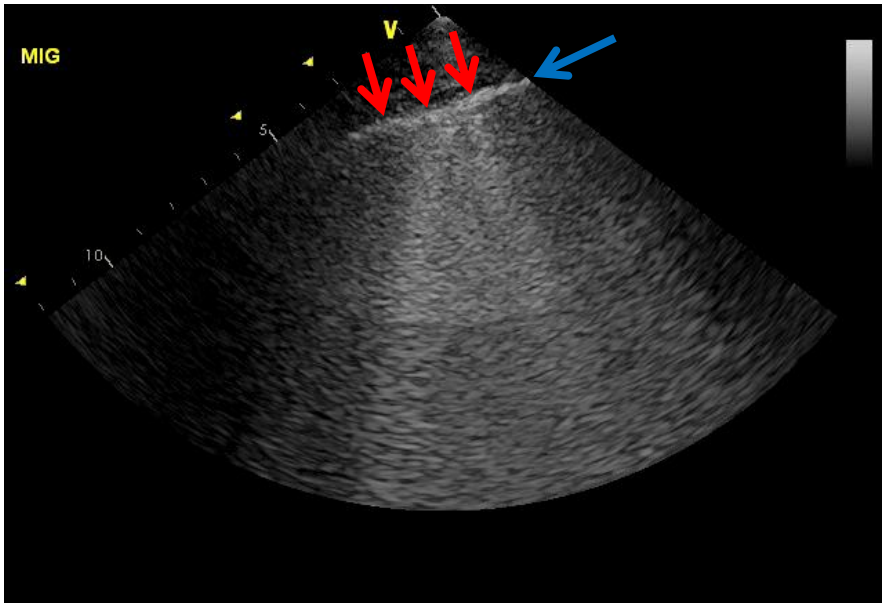
Post-exercise LUS for HFpEF diagnosis: promising

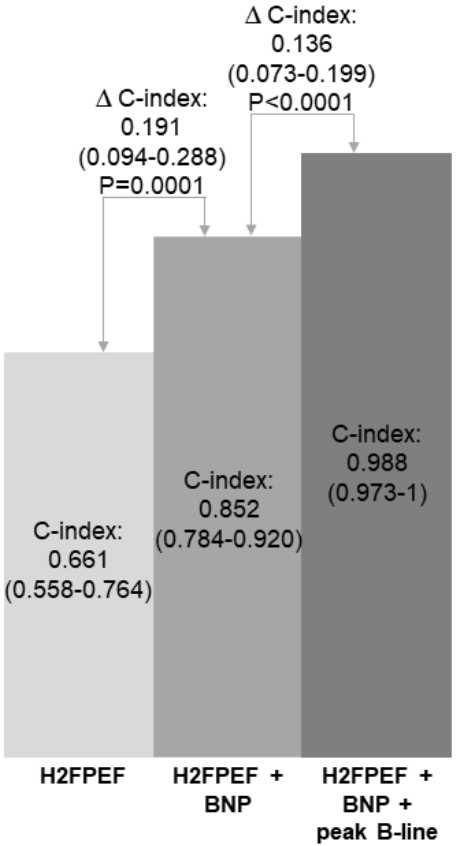


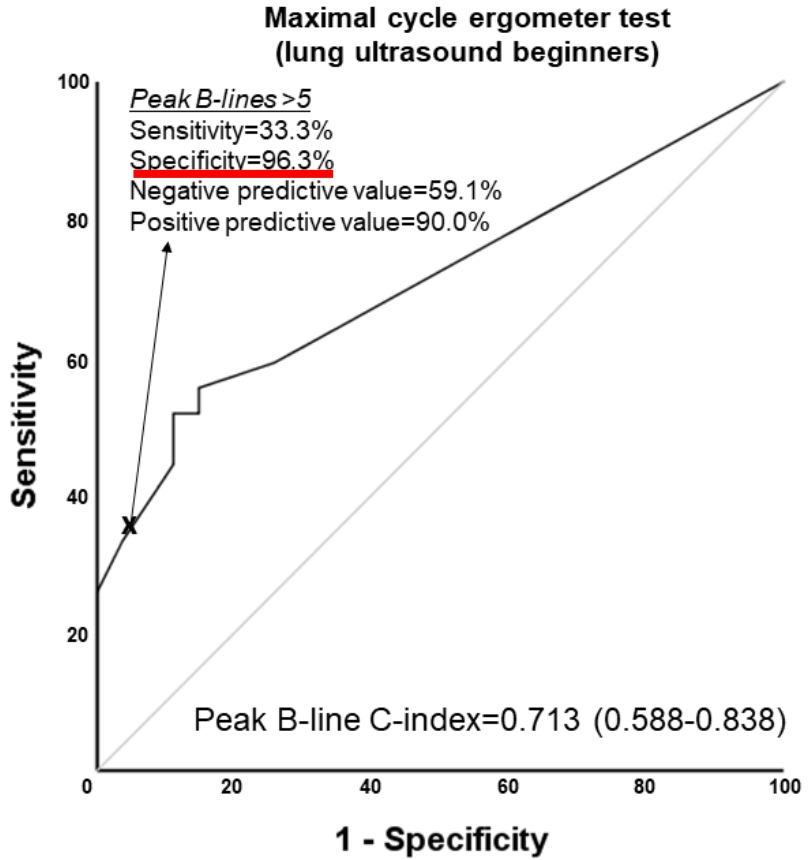
Baseline



Post-exercise B-Lines

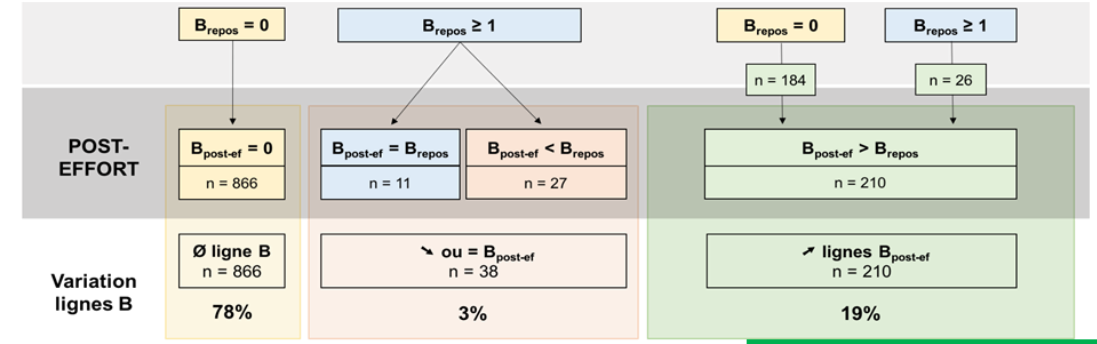






Coiro S et al, Clin Res Cardiol 2023

Congestion pulmonaire induite à l'effort, n=1114, FEVG >50%



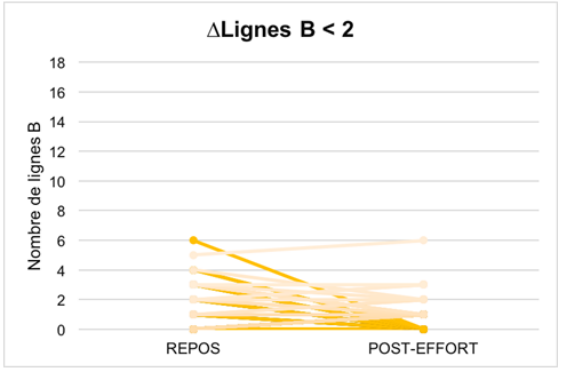
Congestion pulmonaire induite à l'effort = 12%

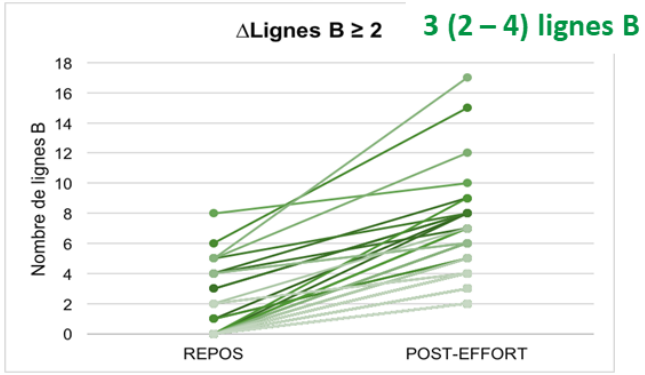
B.

ΔLignes B

ΔLignes B < 2
n = 983
88%

ΔLignes B ≥ 2
n = 131
12%





Dr Camille Granger, Thèse de médecine

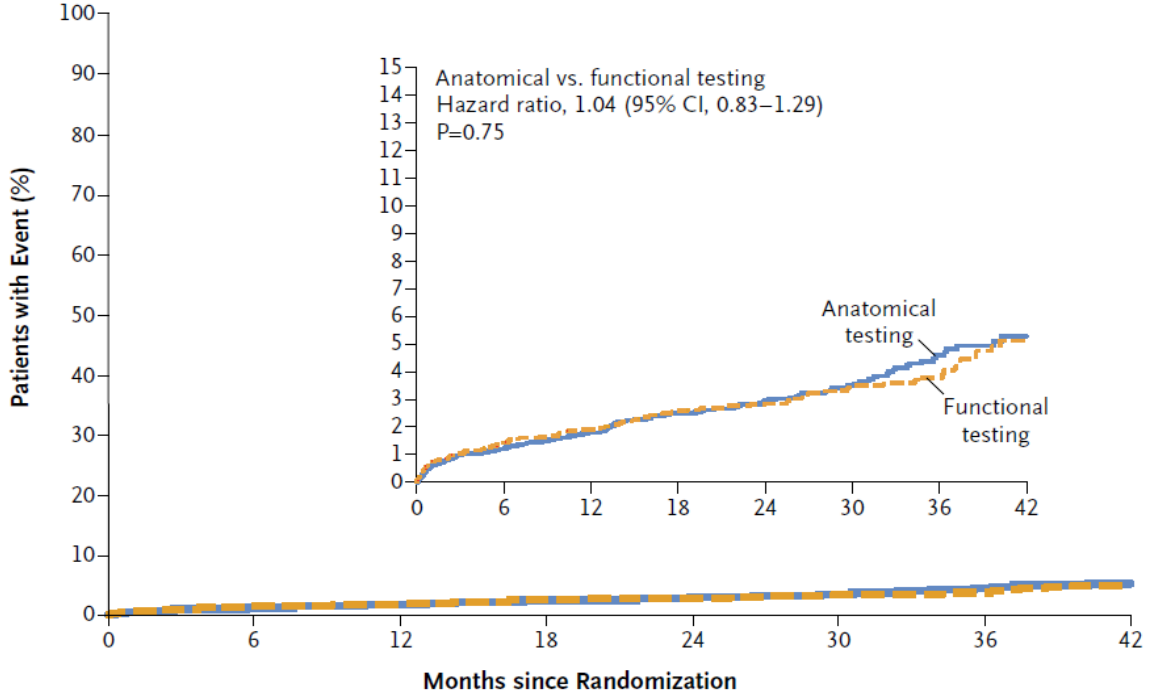
Exercise echo to rule out ischemia

	Diagnosis of CAD	
	Sensitivity (%)	Specificity (%)
Exercise ECG [a, 91, 94, 95]	45–50	85–90
Exercise stress echocardiography[96]	80–85	80–88
Exercise stress SPECT[96-99]	73–92	63–87
Dobutamine stress echocardiography[96]	79–83	82–86
Dobutamine stress MRI[b,100]	79–88	81–91
Vasodilator stress echocardiography[96]	72–79	92–95
Vasodilator stress SPECT[96, 99]	90–91	75–84
Vasodilator stress MRI[b,98, 100-102]	67–94	61–85
Coronary CTA[c,103-105]	95–99	64–83
Vasodilator stress PET[97, 99, 106]	81–97	74–91

ESC guidelines, 2013

ESTABLISHED IN 1812 APRIL 2, 2015 VOL. 372 NO. 14

Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease

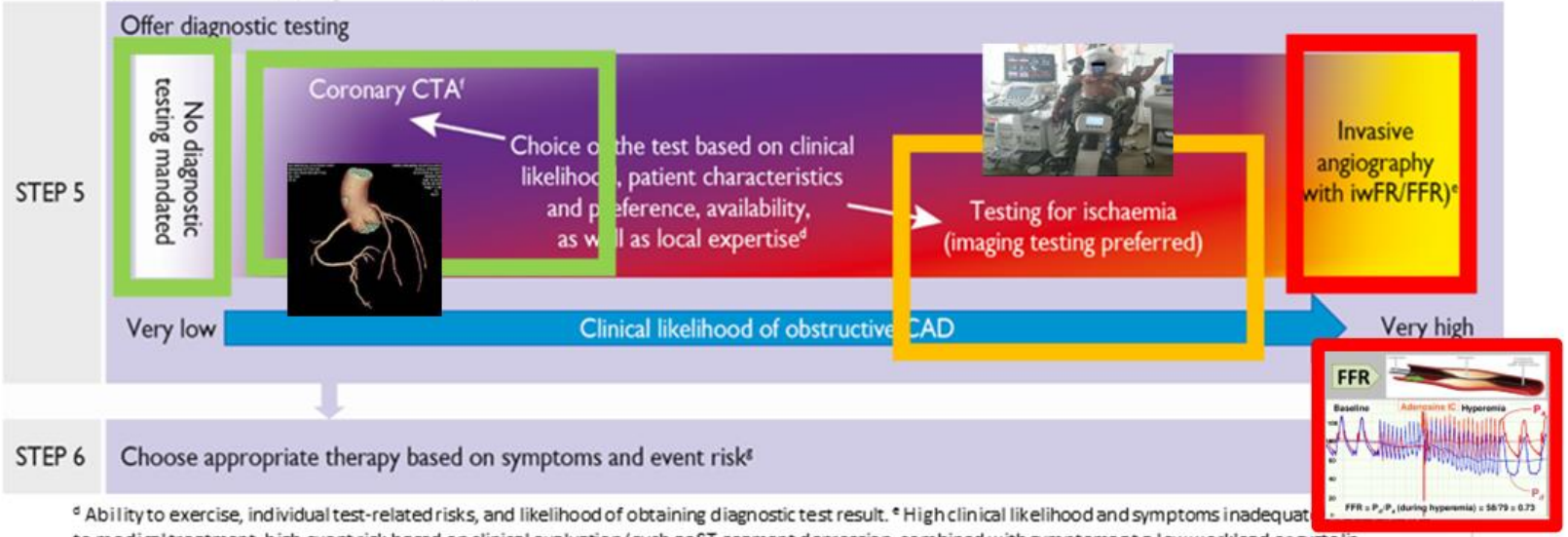


No. at Risk

Anatomical testing	4996	4703	4362	3551	2652	1705	902	269
Functional testing	5007	4536	4115	3331	2388	1518	832	258

Patients with angina and/or dyspnoea and suspected coronary artery disease

Diagnostic approach (2)



[d] Ability to exercise, individual test-related risks, and likelihood of obtaining diagnostic test result. [e] High clinical likelihood and symptoms inadequat to medical treatment, high event risk based on clinical evaluation (such as ST-segment depression, combined with symptoms at a low workload or systolic dysfunction indicating CAD), or uncertain diagnosis on non-invasive testing. [f] Functional imaging for myocardial ischaemia if coronary CTA has shown CAD of uncertain grade or is non-diagnostic. [g] Consider also angina without obstructive disease in the epicardial coronary arteries (see section 6 of full text).

www.escardio.org/guidelines

ESC Guidelines on the diagnosis and management of chronic coronary syndromes (European Heart Journal 2019; 10.1093/eurheartj/ehz425)

PHYSICAL FITNESS AS A PREDICTOR OF MORTALITY AMONG HEALTHY, MIDDLE-AGED NORWEGIAN MEN

Leiv Sandvik, M.Sc., Jan Erikssen, M.D., D.Sc., Erik Thaulow, M.D., D.Sc., Gunnar Erikssen, M.D., Reidar Mundal, M.D., and Kaare Rodahl, M.D., D.Sc.

n≈2000 men (40 to 59 years)
Follow-up of 16 years

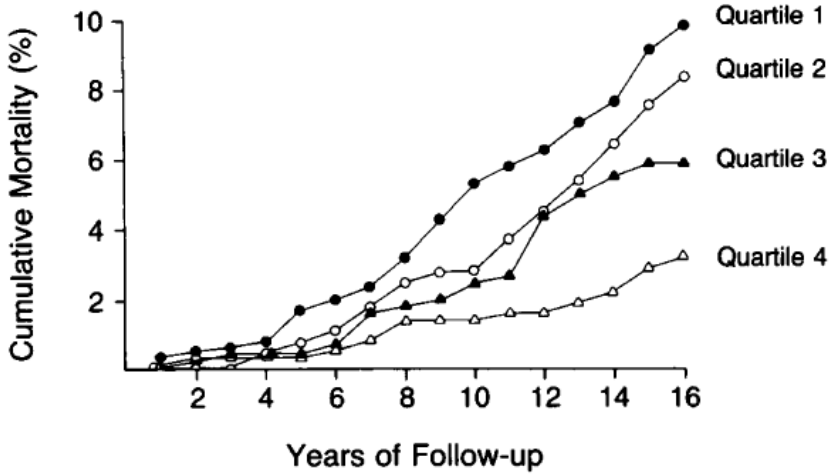


Figure 1. Cumulative Age-Adjusted Mortality from Cardiovascular Causes over 16 Years of Follow-up, According to Fitness Quartile.

N Engl J Med 1993;328:533-7

Conclusion

The **diagnosis of HFpEF remains challenging** in non congestive patients

-BNP could miss the diagnosis

-Echocardiography (even multiparametric approach) could be inconclusive

Echo stress testing for “diastole” **should be interpreted with caution**

-E/e’ a bad parameter

-TRV useful but feasible in only 30% of patients (low level > 3.5m/s?)

-**post exercise B-lines: promising**

Echo stress testing: very useful to rule out ischemia

Invasive exercise hemodynamics could be considered in some symptomatic patients (those requiring coronary angiography ?)

MERCI

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DOI: 10.1111/eci.13664

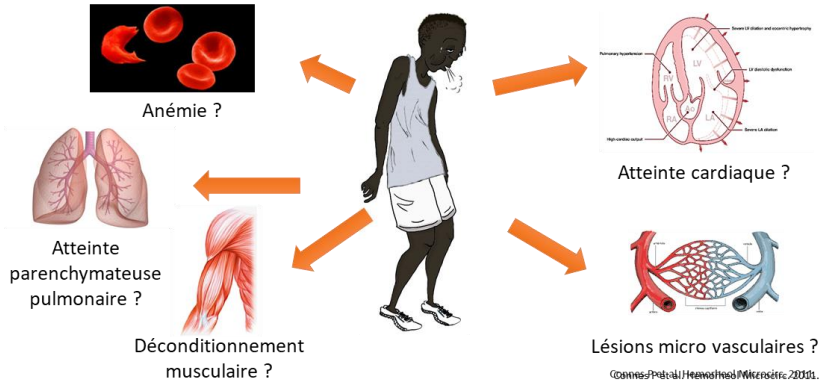
ORIGINAL ARTICLE

WILEY

Altered cardiac reserve is a determinant of exercise intolerance in sickle cell anaemia patients

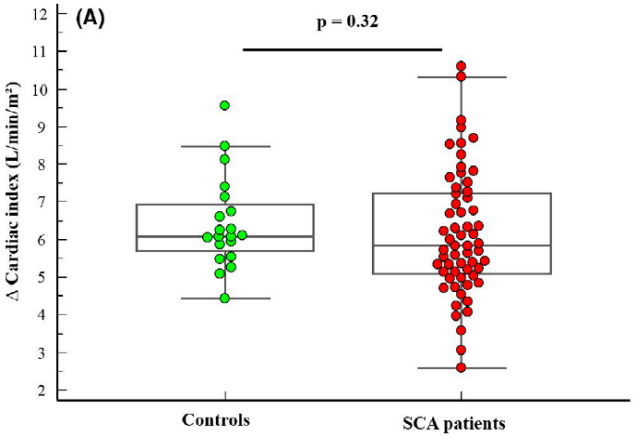
Nadjib Hammoudi[1] | Alexandre Ceccaldi[1] | Jean-Philippe Haymann[2] | Paul Guedeney[1] | Fadila Nicolas-Jilwan[2] | Michel Zeitouni[1] | Gilles Montalescot[1] | François Lionnet[3] | Richard Isnard[1] | Stéphane N. Hatem[1]

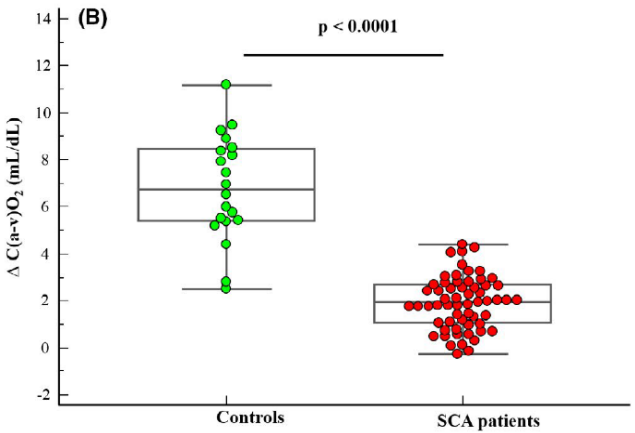
Intolérance à l'effort

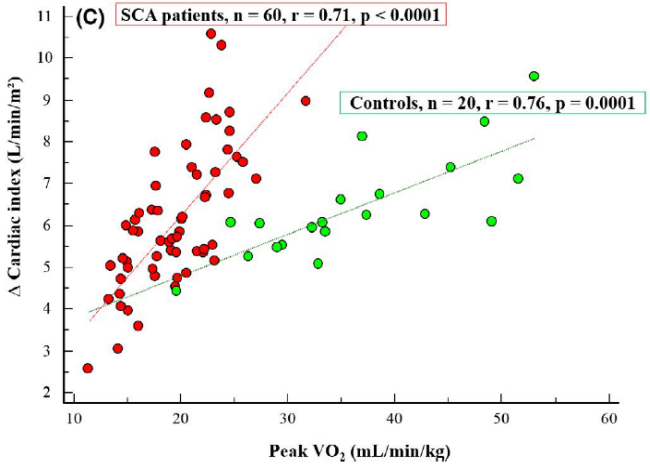


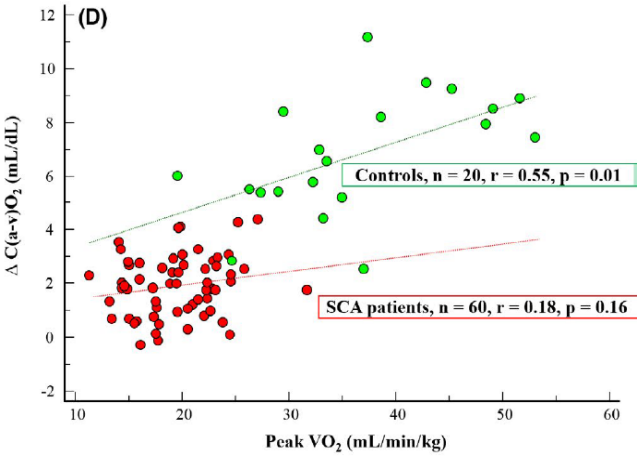
Intérêt des études combinées

ETT d'effort couplée à l'EFX		
VO2	IC	DAVO2
Mesurée par EFX	Mesuré par ETT	Calculée selon Fick : DAVO2 = VO2 / IC


(A)
p = 0.32
Δ Cardiac index (L/min/m²)
Controls
SCA patients


(B)
p < 0.0001
Δ C(a-v)O2 (mL/dL)
Controls
SCA patients


(C)
SCA patients, n = 60, r = 0.71, p < 0.0001
Controls, n = 20, r = 0.76, p = 0.0001
Δ Cardiac index (L/min/m²)
Peak VO2 (mL/min/kg)


(D)
Controls, n = 20, r = 0.55, p = 0.01
SCA patients, n = 60, r = 0.18, p = 0.16
Δ C(a-v)O2 (mL/dL)
Peak VO2 (mL/min/kg)

Résultats – **Déterminants de la congestion pulmonaire**

Analyse univariée

REPOS

	Total *n* = 1114	ΔLignes B < 2 *n* = 983	ΔLignes B ≥ 2 *n* = 131	*p*
Données cliniques et antécédents cardiovasculaires				
Age (ans, moyenne ± DS)	63 ± 11	62 ± 11	65 ± 12	**0,041**
Sexe masculin, n (%)	811 (73)	710 (72)	101 (77)	0,24
IMC (kg/m², moyenne ± DS)	26 ± 4	26 ± 3	26 ± 4	0,86
Obésité (IMC >30kg/m²), n (%)	188 (17)	165 (17)	23 (18)	0,82
Tabagisme actif, n (%)	173 (16)	154 (16)	19 (15)	0,66
Diabète, n (%)	292 (27)	263 (28)	29 (22)	0,21
Hypertension artérielle, n (%)	584 (54)	513 (56)	71 (55)	0,85
Dyslipidémie, n (%)	648 (60)	573 (60)	75 (58)	0,55
CPI, n (%)	624 (57)	555 (58)	69 (53)	0,31
Antécédent de FA, n (%)	59 (5)	50 (5,3)	9 (6,9)	0,43
Traitements				
IEC ou ARA 2, n (%)	622 (58)	551 (58)	71 (55)	0,47
Traitement bradycardisant, n (%)	638 (57)	557 (58)	79 (61)	0,55
Bétabloquants, n (%)	587 (54)	515 (54)	72 (56)	0,69
ICa bradycardisant, n (%)	61 (6)	54 (5,7)	7 (5,4)	0,91
Diurétiques#, n (%)	182 (17)	164 (17)	18 (14)	0,33

	Total *n* = 1114	ΔLignes B < 2 *n* = 983	ΔLignes B ≥ 2 *n* = 131	*p*
Echocardiographie au repos				
FEVG (%, moyenne ± DS)	61 ± 6	61 ± 6	62 ± 5	0,26
Masse VGi (g/m², moyenne ± DS)	77 ± 21	77 ± 21	79 ± 22	0,34
VTDVGi (mL/m², moyenne ± DS)	69 ± 18	69 ± 18	70 ± 18	0,86
ICd (L/min/m², moyenne ± DS)	2,9 ± 0,8	2,9 ± 0,8	2,8 ± 0,8	0,53
VOGi (mL/m², médiane, IQR)	28 ± 10	26 (21 – 33)	28 (23 – 35)	**0,033**
OG dilatée (>34mL/m², n %)	231 (21)	202 (21)	34 (26)	0,16
OG dilatée (>40mL/m², n %)	119 (11)	97 (10)	22 (17)	**0,017**
E/e'$_{septal}$ repos (médiane, IQR)	9,8 (7,9 – 12)	9,8 (7,9 – 12)	10 (8,5 – 12)	0,13
E/e'$_{septal}$ < 8, n (%)	283 (26)	258 (27)	25 (19)	0,072
E/e'$_{septal}$ > 15, n (%)	102 (9)	82 (8,5)	20 (16)	**0,01**
VmaxIT (m/s, moyenne ± DS) *	2,3 ± 0,2	2,3 ± 0,2	2,3 ± 0,3	0,61
VmaxIT > 2.8m/s, n (%) *	10 (2,8)	9 (2,9)	1 (2,2)	1
TAPSE (mm, moyenne ± DS)	24 ± 5	24 ± 5	23 ± 5	0,73

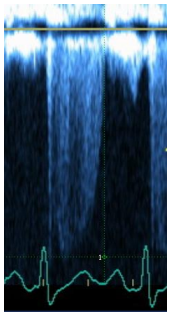
* *n*= 359. #Diurétiques de l'anse et/ou diurétiques thiazidiques.

Résultats – Déterminants de la congestion pulmonaire

EFFORT

Analyse univariée

	Total *n* = 1114	ΔLignes B < 2 *n* = 983	ΔLignes B ≥ 2 *n* = 131	*p*
Données de l'épreuve d'effort				
Epreuve maquillée, n (%)	461 (42)	400 (41)	61 (47)	0,23
Motif d'arrêt				
Fatigue, n (%)	921 (83)	812 (83)	109 (83)	1
Dyspnée, n (%)	168 (15)	147 (15)	21 (16)	0,87
Douleur thoracique, n (%)	2 (0,2)	2 (0,2)	0 (0)	1
Autre, n (%)	18 (1,6)	17 (1,7)	1 (0,8)	0,71
PA (mmHg, moyenne ± DS)				
PAS repos	145 ± 20	144 ± 20	146 ± 19	0,29
PAD repos	86 ± 13	86 ± 13	87 ± 13	0,6
PAS au pic	210 ± 29	210 ± 29	213 ± 27	0,2
PAD au pic	98 ± 20			
FC maximale (bpm, moyenne ± DS)	137 ± 2			
%FMT (moyenne ± DS)	87 ± 13			
METS (moyenne ± DS)	7 ± 1,8			
%METS$_{th}$ (moyenne ± DS)	90 ± 21			
Pic de Watts (moyenne ± DS)	130 ± 4			
BORG /10 (moyenne ± DS)	6 ± 2			
FA pendant l'effort, n (%)	16 (1,4			



IT au pic = 23%

(n = 257)

	Total *n* = 1114	ΔLignes B < 2 *n* = 983	ΔLignes B ≥ 2 *n* = 131	*p*
Données d'échographie à 20W				
20W FEVG (%, moyenne ± DS)	66 ± 6	66 ± 6	66 ± 6	0,54
20W ICd (L/min/m^2, moyenne ± DS)	4,1 ± 1,1	4,1 ± 1,1	4,1 ± 1,1	0,8
20W VTDVGi (L/min/m^2, moyenne ± DS)	72 ± 17	72 ± 17	74 ± 18	0,24
20W E/e'$_{septal}$ (médiane, IQR)	9,8 (7,9 – 12)	9,6 (7,9 – 11,9)	10,4 (8,4 – 13,2)	**<0,01**
20W E/e'$_{septal}$ > 15, n (%)	120 (11)	95 (10)	25 (19)	**<0,01**
20W VmaxIT (m/s, moyenne ± DS) #	2,8 ± 0,3	2,8 ± 0,3	2,8 ± 0,4	0,2
20W VmaxIT > 3,4m/s, n (%) #	11 (3,3)	9 (3,1)	2 (4,3)	0,65
Données d'échographie au pic				
Pic FEVG (%, moyenne ± DS)	70 ± 7	70 ± 7	70 ± 6	0,6
Pic ICd (L/min/m^2, moyenne ± DS)	6,8 ± 1,9	6,8 ± 2	6,8 ± 2	0,98
Pic VTDVGi (mL/min/m^2, moyenne ± DS)	72 ± 17	71 ± 17	74 ± 19	0,21
Pic E/e'$_{septal}$ (médiane, IQR)	9,7 (7,8 – 12)	9,5 (7,8 – 12)	10 (8,5 – 13)	**0,014**
Pic E/e'$_{septal}$ > 15, n (%)	124 (12)	104 (11)	20 (16)	0,12
Pic VmaxIT (m/s, moyenne ± DS) #	3,2 ± 0,4	3,2 ± 0,4	3,4 ± 0,3	**<0,01**
Pic VmaxIT > 3,4m/s, n (%) #	67 (26)	51 (24)	16 (39)	**0,039**

¶ n =332. # n = 257.

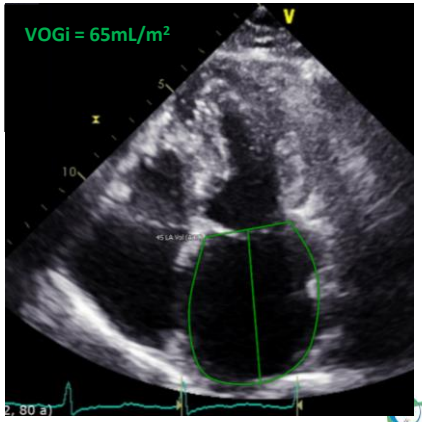
Dr Camille Granger, Thèse de médecine

Résultats – Déterminants de la congestion pulmonaire **Analyses multivariées**

Modèle multivarié 1

(âge, le volume de l'OG, le rapport E/e'$_{septal}$ au repos, à 20W et au pic de l'effort)

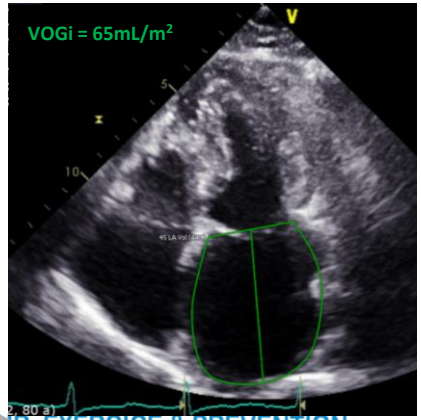
Volume indexé de l'OG
OR = 1,03
IC95 : 1,01 – 1,04; ***p* = 0,003**



Modèle multivarié 2

(idem 1 + VmaxIT) ***(n = 257)***

Volume indexé de l'OG
OR = 1,03
IC95 : 1 – 1,06; ***p* = 0,04**



VmaxIT au pic de l'effort
OR = 3,8
IC95 : 1,4 – 10,1; ***p* = 0,009**

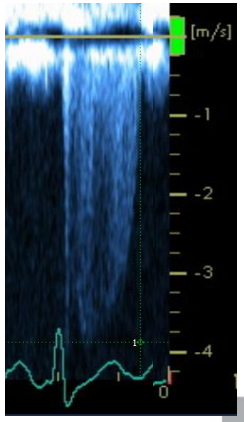
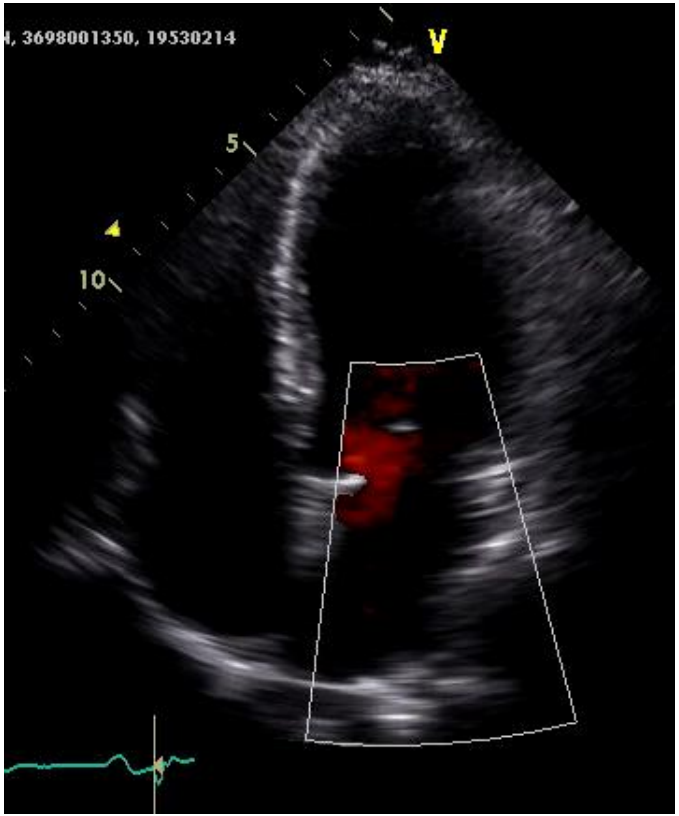
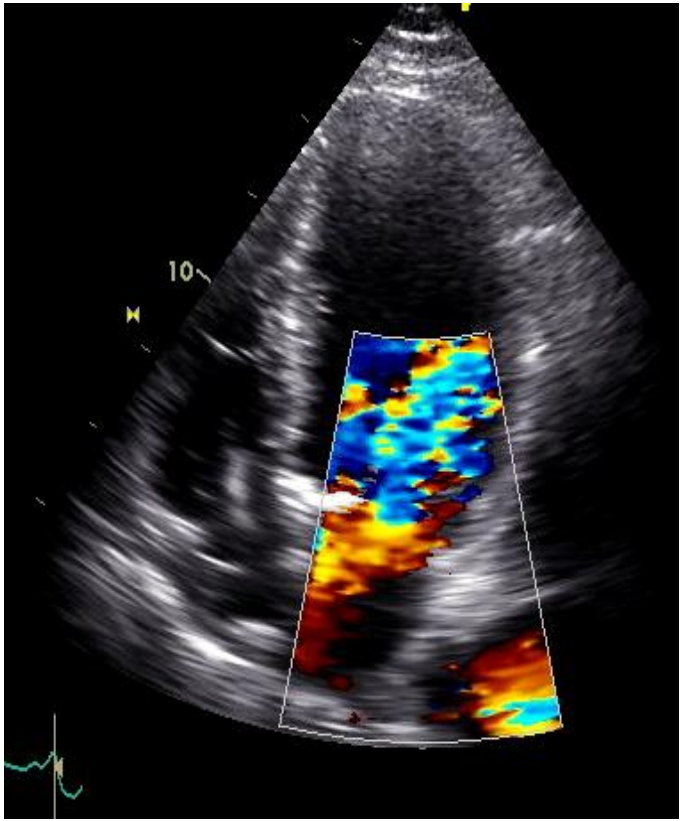


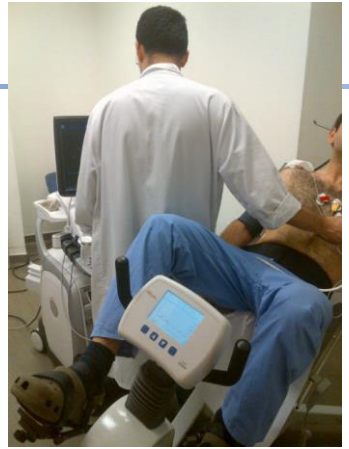
Table 4. Classification of HF by LVEF

Type of HF According to LVEF	Criteria
HFrEF (HF with reduced EF)	LVEF ≤40%
HFimpEF (HF with improved EF)	Previous LVEF ≤40% and a follow-up measurement of LVEF >40%
HFmrEF (HF with mildly reduced EF)	LVEF 41%–49% Evidence of spontaneous or provokable increased LV filling pressures (eg, elevated natriuretic peptide, noninvasive and invasive hemodynamic measurement)
HFpEF (HF with preserved EF)	LVEF ≥50% Evidence of spontaneous or provokable increased LV filling pressures (eg, elevated natriuretic peptide, noninvasive and invasive hemodynamic measurement)

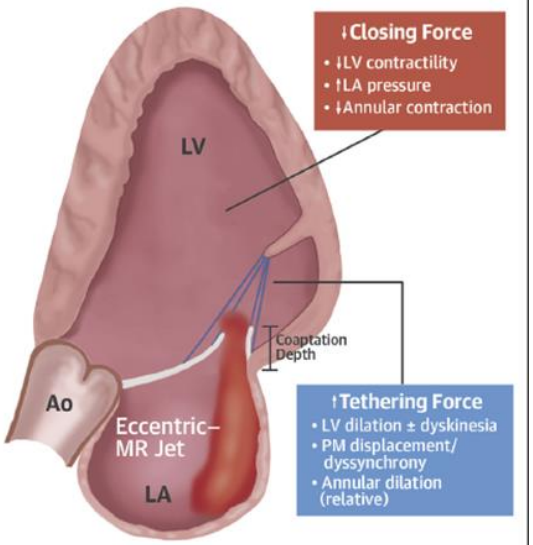
Secondary MR







Secondary Mitral Regurgitation

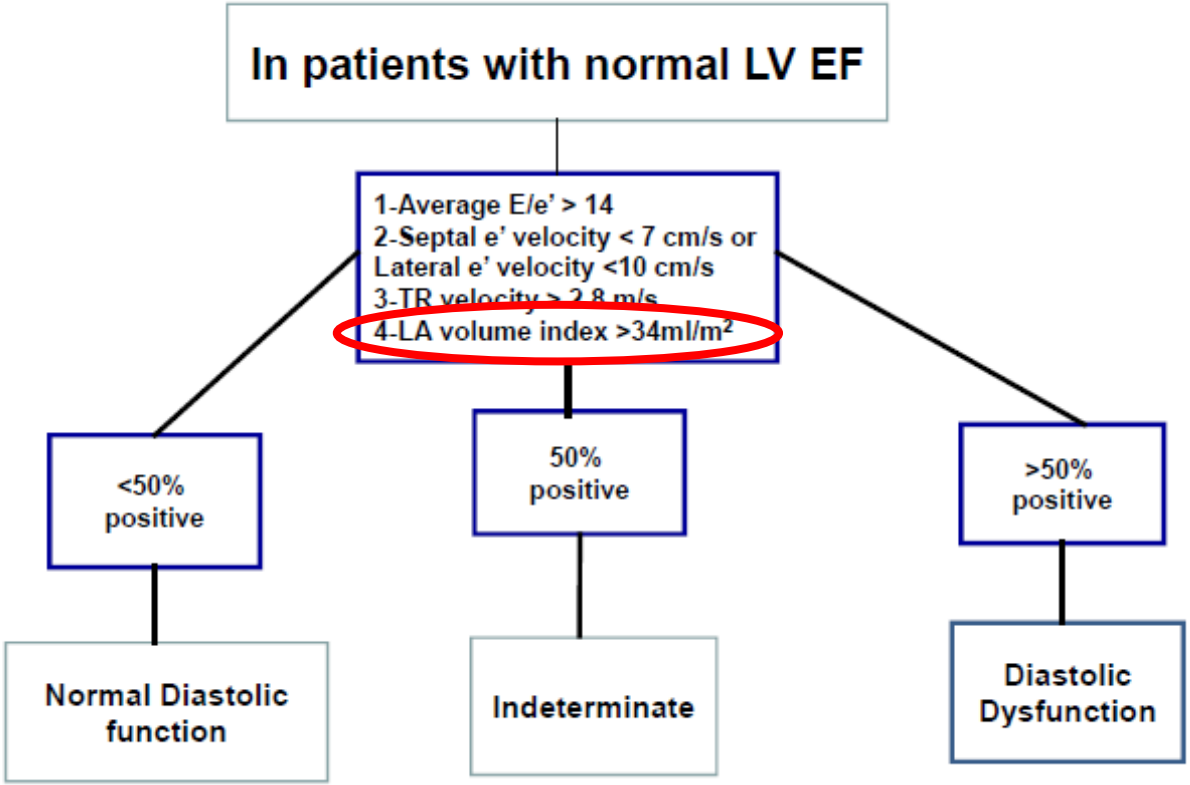


Etiology and Prevalence

- 11%-59% post myocardial infarction
- >50% in dilated cardiomyopathy

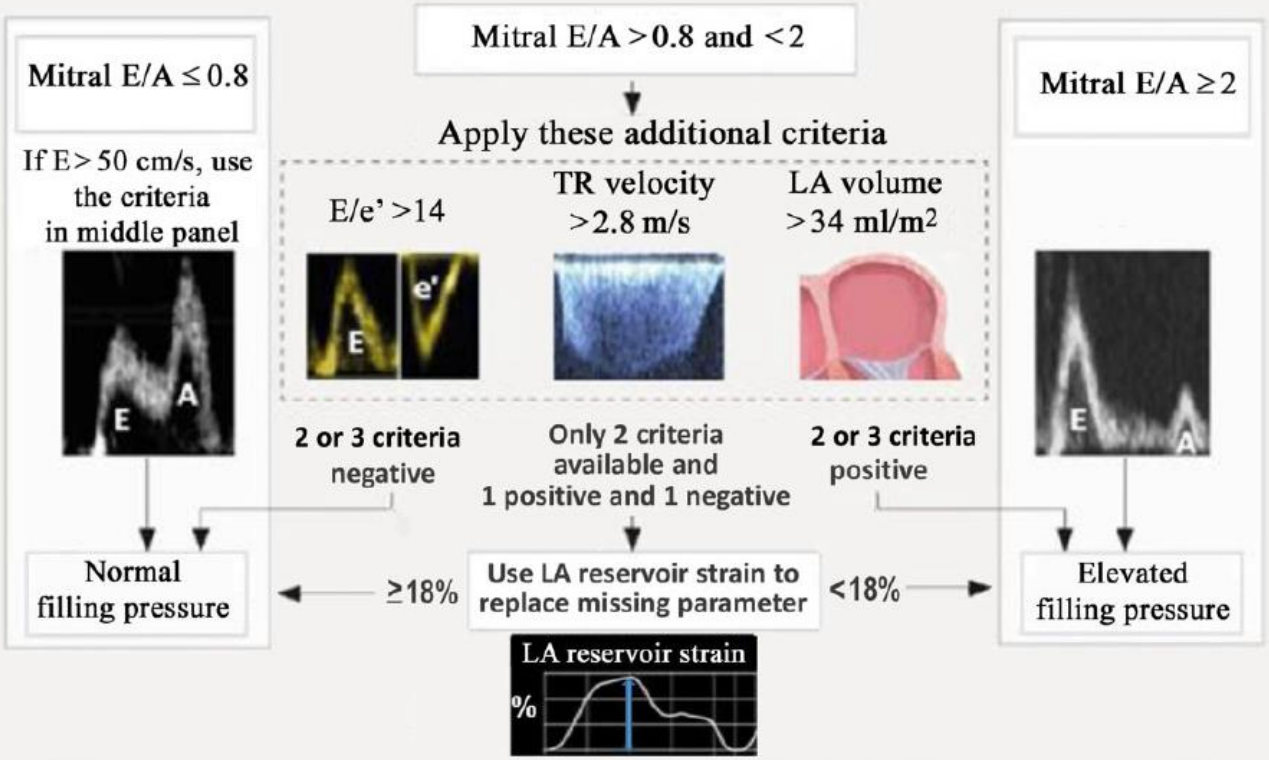
Deferm S. Atrial Functional Mitral Regurgitation, JACC, 2019

A



(J Am Soc Echocardiogr 2016;29:277-314.)

Estimation of left ventricular filling pressure



ESC European Society of Cardiology

European Heart Journal (2019) **00**, 1–21
doi:10.1093/eurheartj/ehz641

How to diagnose heart failure with preserved ejection fraction: the HFA–PEFF diagnostic algorithm: a consensus recommendation from the Heart Failure Association (HFA) of the European Society of Cardiology (ESC)

Burkert Pieske[1,2,3,4]*, Carsten Tschöpe[1,2,5], Rudolf A. de Boer [6], Alan G. Fraser[7], Stefan D. Anker[1,2,5,8], Erwan Donal[9], Frank Edelmann[1,2], Michael Fu[10], Marco Guazzi[11,12], Carolyn S.P. Lam[13,14], Patrizio Lancellotti[15], Vojtech Melenovsky[16], Daniel A. Morris[1], Eike Nagel [17,18], Elisabeth Pieske-Kraigher[1], Piotr Ponikowski[19], Scott D. Solomon[20], Ramachandran S. Vasan[21], Frans H. Rutten [22], Adriaan A. Voors[6], Frank Ruschitzka[23], Walter J. Paulus[24], Petar Seferovic[25] and Gerasimos Filippatos[26,27]

B

HFA-PEFF Score

P Pretest assessment

- Symptoms and/or signs of heart failure
- Comorbidities/risk factors
- Standard echocardiography

E Echo and natriuretic peptide score

- Comprehensive echocardiography
- Natriuretic peptides

F1 Functional testing in case of uncertainty

- Diastolic stress test (exercise echocardiography)
- Invasive hemodynamic measurements

F2 Final etiology

- Special imaging (CMR, CT, PET, scintigraphy)
- Biopsies
- Genetic testing

Functional
Septal e' <7 cm/s or
Lateral e' <10 cm/s or
Average E/e' ≥15 or
TR velocity >2.8 m/s

Average E/e' 9-14 or
GLS <16%

Morphological
LAVI >34 mL/m² or
LVMI ≥149/122 g/m² (M/F) and
RWT >0.42

LAVI 29.34 or
LVMI >115/95 g/m² (M/F) or
RWT >0.42 or
LV wall thickness ≥12 mm

Biomarker (Sinus rhythm)
NT-proBNP >220 pg/mL or
BNP >80 pg/mL

NT-proBNP 125-220 pg/mL or
BNP 35-80 pg/mL

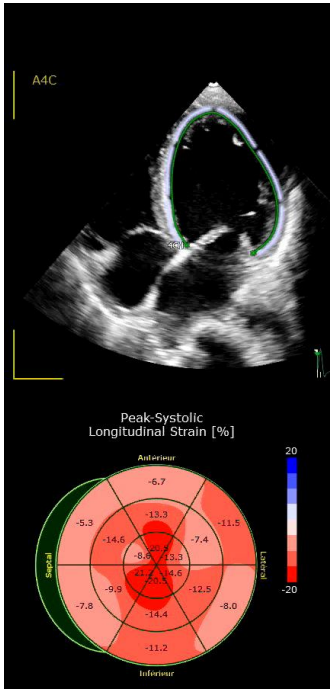
Biomarker (Atrial Fibrillation)
NT-proBNP >660 pg/mL or
BNP >240 pg/mL

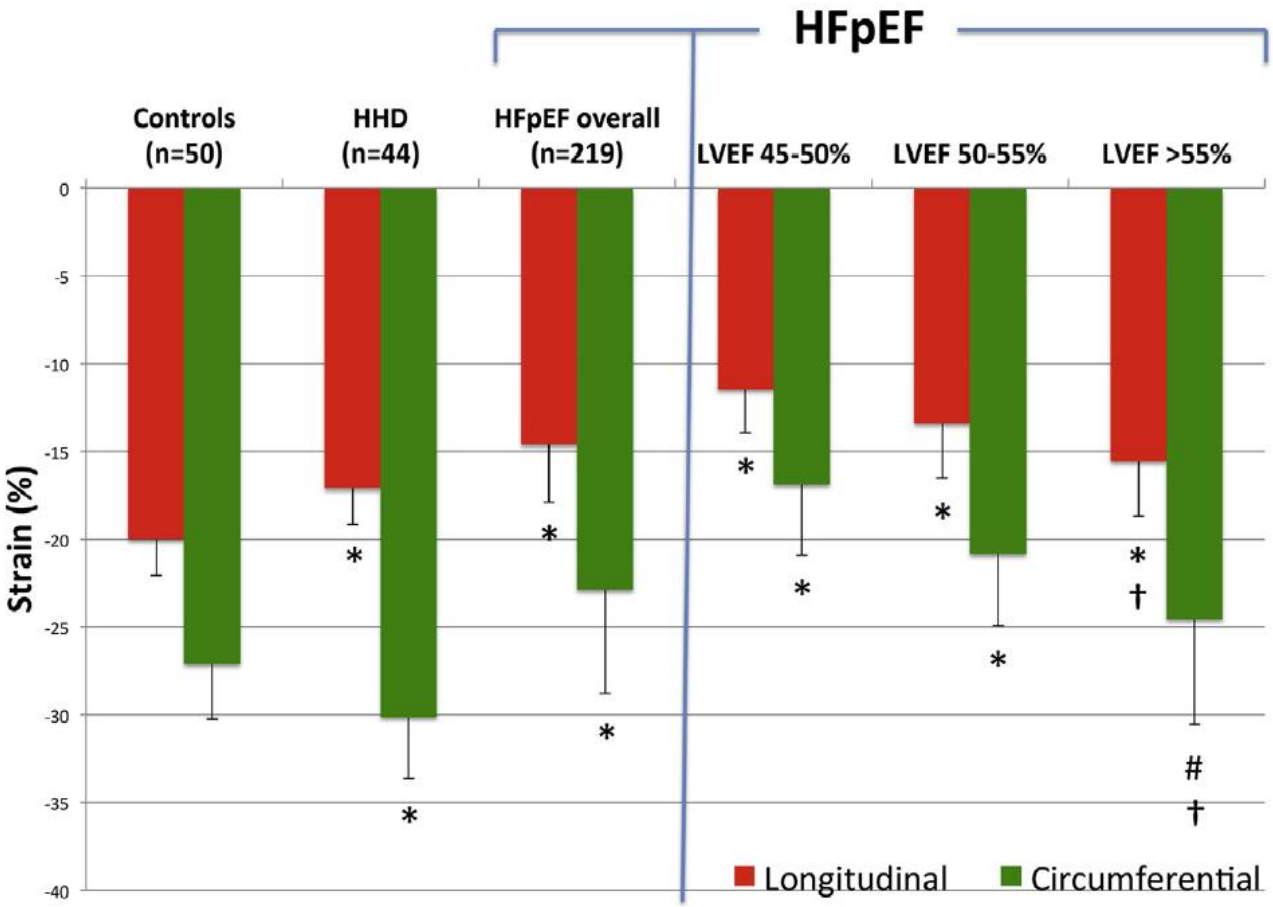
NT-proBNP 365-660 pg/mL or
BNP 105-240 pg/mL

≥5 points: HFpEF
Major criteria (2 pts): bolded
Minor criteria (1 pt): non-bolded

	Functional	Morphological	Biomarker (SR)	Biomarker (AF)
Major	septal e' < 7 cm/s or lateral e' < 10 cm/s or Average E/e' ≥ 15 or TR velocity > 2.8 m/s (PASP > 35 mmHg)	LAVI > 34 ml/m² or LVMI ≥ 149/122 g/m² (m/w) and RWT > 0,42 #	NT-proBNP > 220 pg/ml or BNP > 80 pg/ml	NT-proBNP > 660 pg/ml or BNP > 240 pg/ml
Minor	Average E/e' 9 -14 or GLS < 16 %	LAVI 29-34 ml/m² or LVMI > 115/95 g/m² (m/w) or RWT > 0,42 or LV wall thickness ≥ 12 mm	NT-proBNP 125-220 pg/ml or BNP 35-80 pg/ml	NT-proBNP 365-660 pg/ml or BNP 105-240 pg/ml

Major Criteria: 2 points	≥ 5 points: HFpEF
Minor Criteria: 1 point	2-4 points: Diastolic Stress Test or Invasive Haemodynamic Measurements



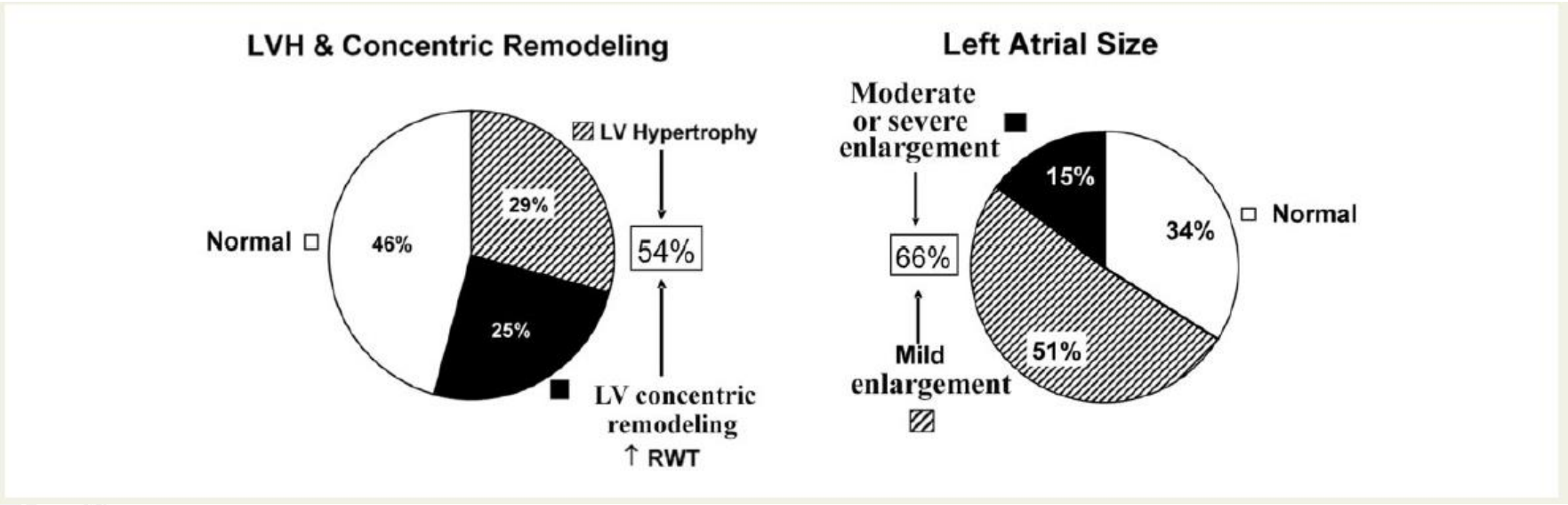


(J Am Coll Cardiol 2014;63:447–56)

LV and LA structural abnormalities

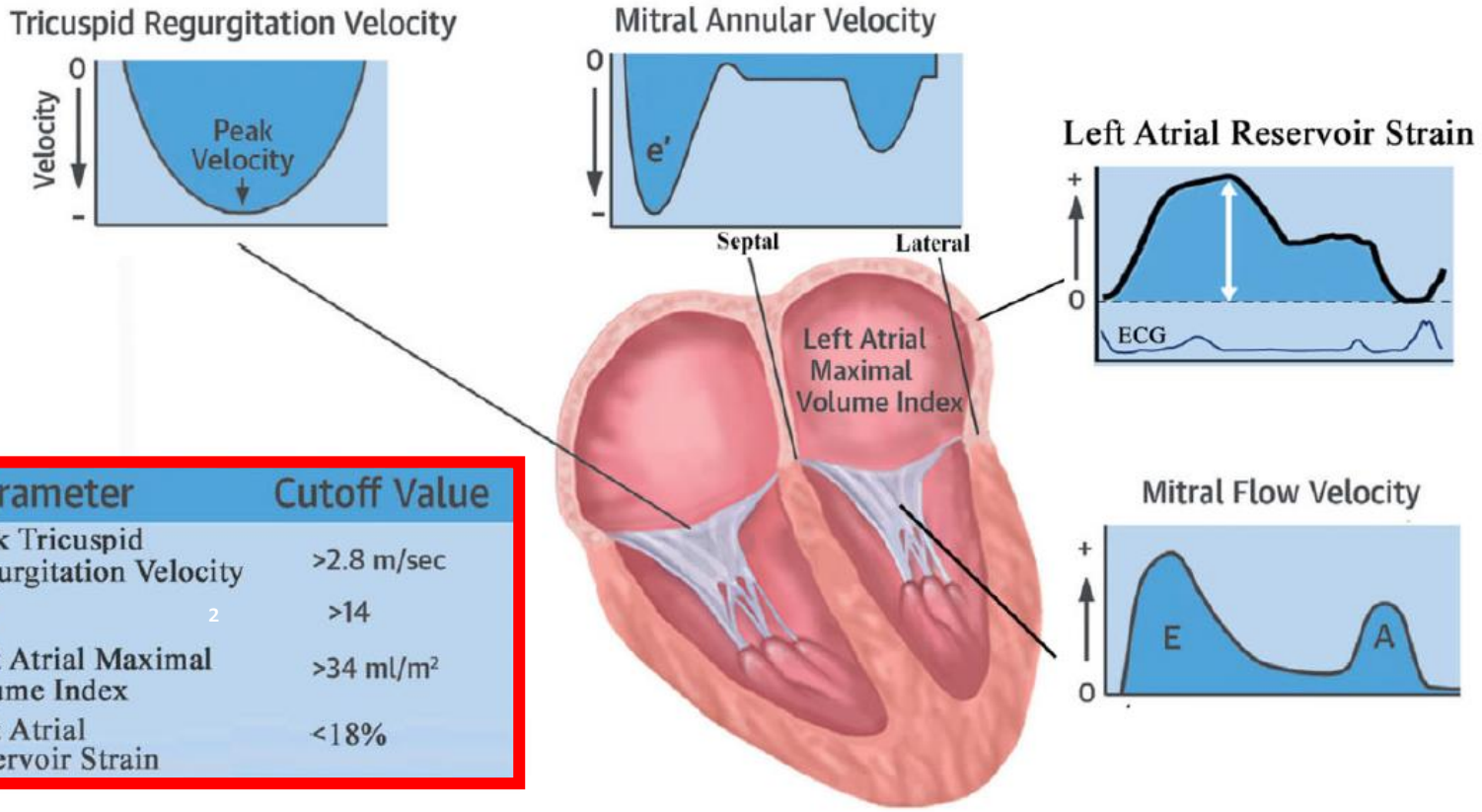
Many HFpEF patients have normal LV and LA morphology:

≈ 30 to 45% of cases



Zile et al, Circulation 2011; Lam et al, Circulation 2007; Shah et al JACC 2019

Echocardiographic Parameters for Estimation of LV Filling Pressure

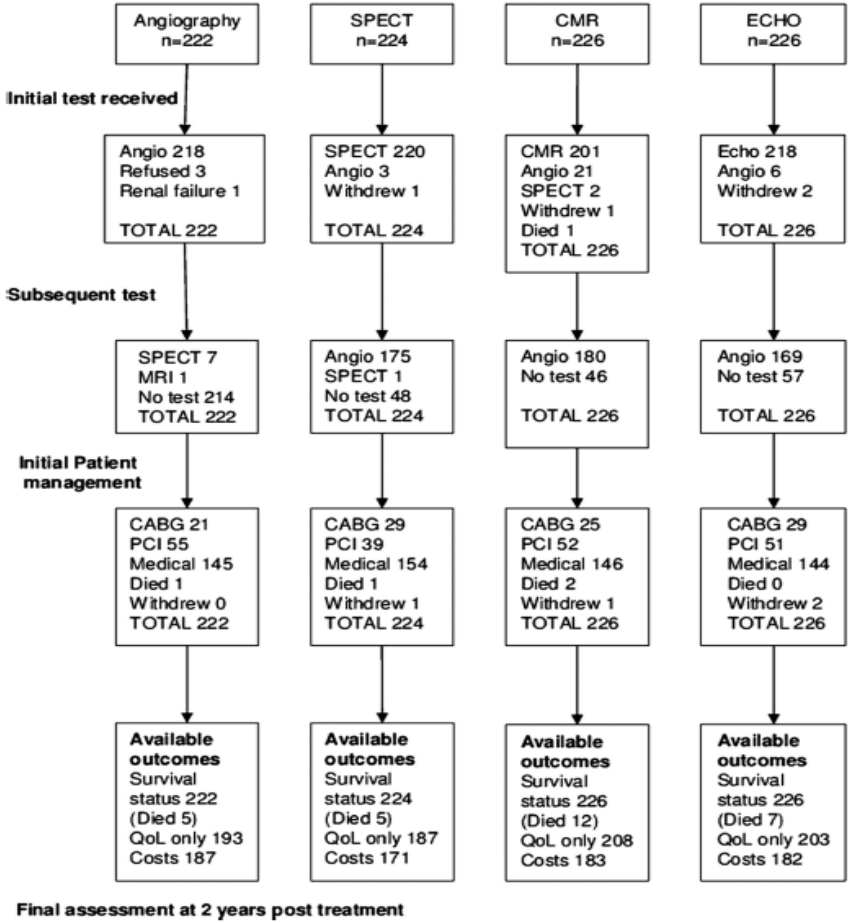


Parameter	Cutoff Value
• Peak Tricuspid Regurgitation Velocity	>2.8 m/sec
• E/e'	>14
• Left Atrial Maximal Volume Index	>34 ml/m²
• Left Atrial Reservoir Strain	<18%

European Heart Journal - Cardiovascular Imaging (2022) 23, e34–e61

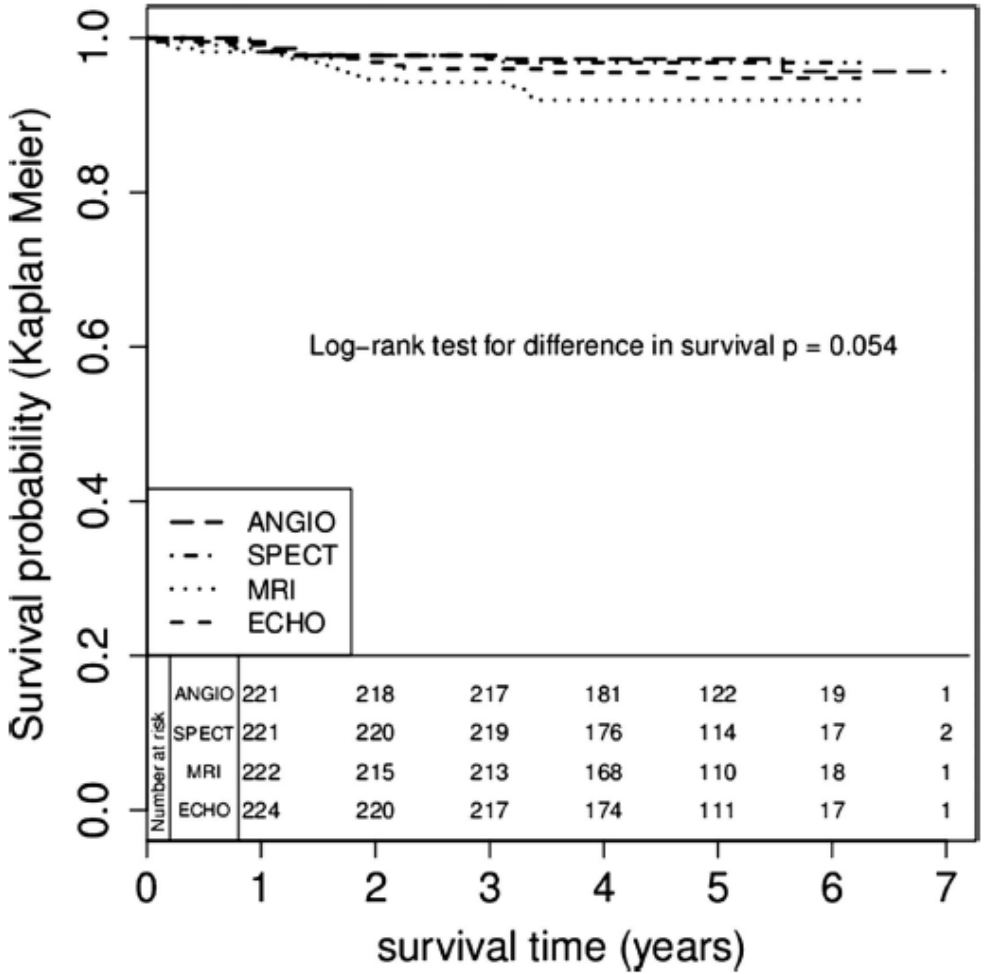
Parameter[a]	Threshold	Comments
LV mass index **Relative wall thickness**	**≥95** g/m^2 (Female), **≥115** g/m^2 (Male) **>0.42**	Although the presence of concentric LV remodelling or hypertrophy is supportive, the absence of LV hypertrophy does not exclude the diagnosis of HFpEF
LA volume index[a]	**>34** mL/m^2 (SR)	In the absence of AF or valve disease, LA enlargement reflects chronically elevated LV filling pressure (in the presence of AF, the threshold is >40 mL/m^2)
E/e' ratio at rest[a]	**>9**	Sensitivity 78%, specificity 59% for the presence of HFpEF by invasive exercise testing, although reported accuracy has varied. A higher cut-off of 13 had lower sensitivity (46%) but higher specificity (86%).[71,259,274]
NT-proBNP **BNP**	**>125** (SR) or **>365** (AF) pg/mL **>35** (SR) or **>105** (AF) pg/mL	Up to 20% of patients with invasively proven HFpEF have NPs below diagnostic thresholds, particularly in the presence of obesity
PA systolic pressure **TR velocity at rest[a]**	**>35** mmHg **>2.8** m/s	Sensitivity 54%, specificity 85% for the presence of HFpEF by invasive exercise testing[259,261]

Étude randomisée : 900 patients adressés pour coronarographie



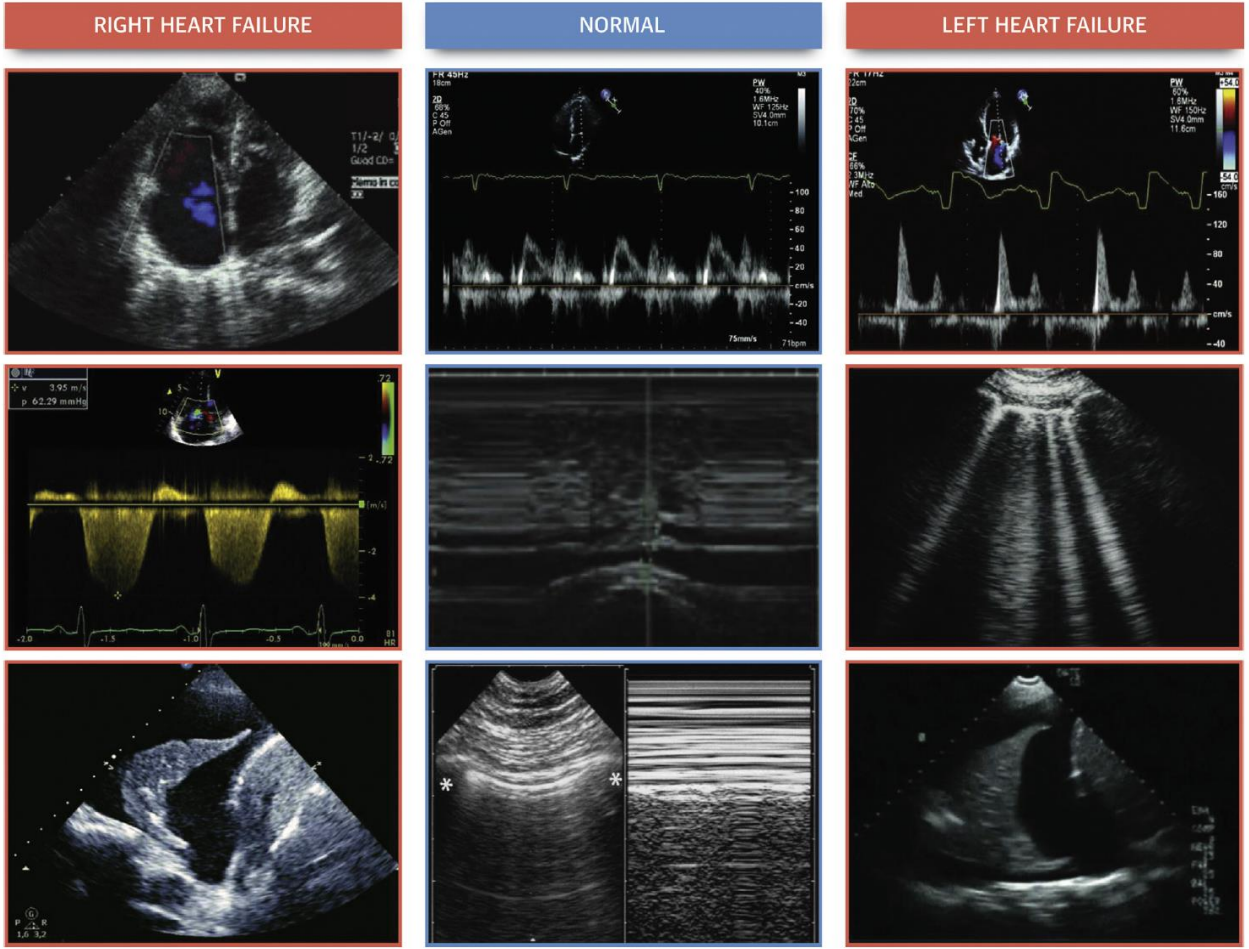
Dans le groupe recherche d'ischémie
≈ - 20 à 25% de coronarographies

Thom H, West NEJ, Hughes V, *et al. BMJ Open* 2014;**4**:e003419.



Thom H, West NEJ, Hughes V, *et al. BMJ Open* 2014;**4**:e003419.

CENTRAL ILLUSTRATION The Shape of Lung Water



Picano, E. et al. J Am Coll Cardiol Img. 2018;11(11):1692–705.