Left Atrial Strain: Clinical Use & Future Directions

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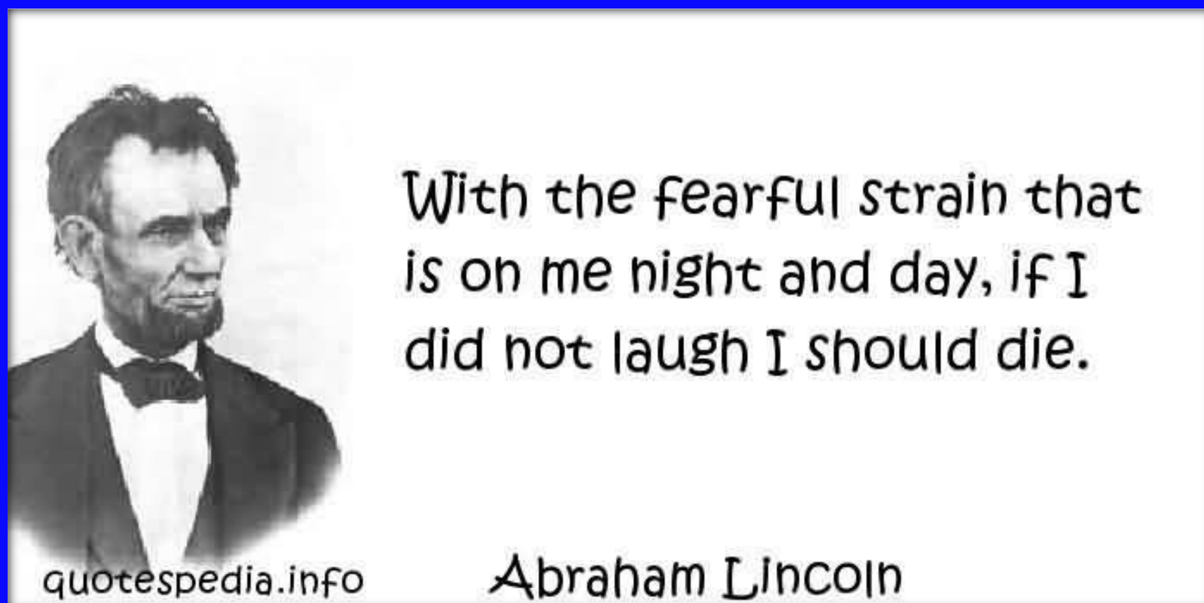
Emek Medical Center

Disclosure

None

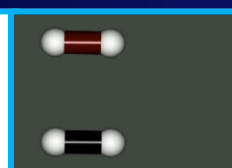
Strain is Pain !

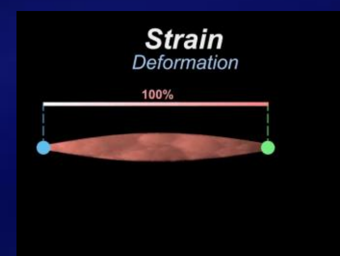


Terminology and Definitions:

- <u>Strain</u> is a dimensionless quantity of myocardial deformation, expressed in percent
- Langrangian strain (ε): The change in myocardial fibre length during stress at end systole compared to its original length in a relax state at end diastole

$$S = \frac{l - l_0}{l_0} = \frac{\Delta l}{l_0}$$





l - Length at contraction
l_0 - Length at origin

- Strain is a valuable tool for assessing myocardial systolic and diastolic function, both regionally and globally

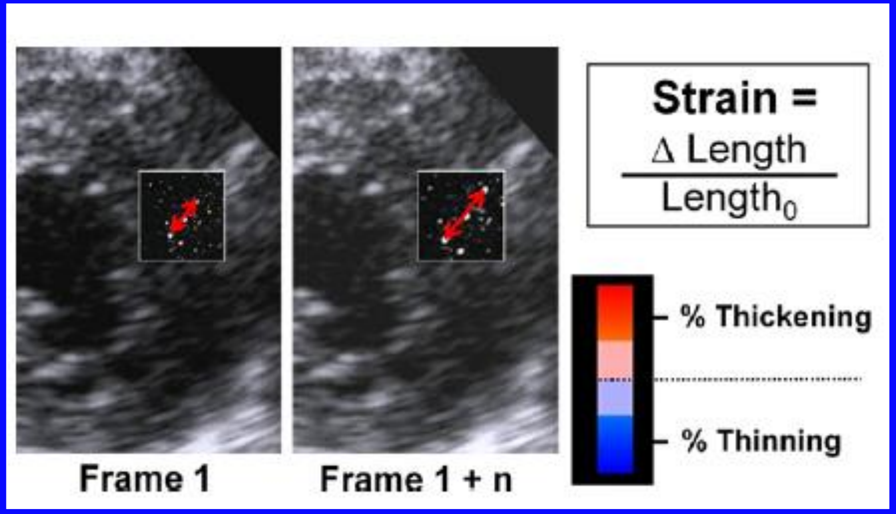
Two- dimensional speckle tracking

Based on frame-to-frame tracking of the grayscale speckles in units called "Kernel"

Accurate tracing of ROI is essential

An angle independent technique

ECG gated



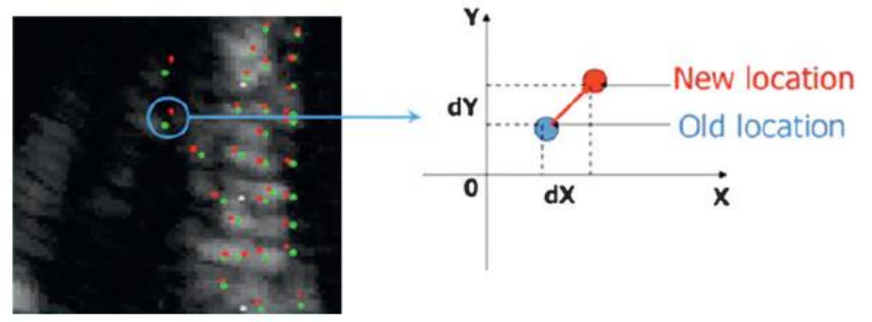


Figure 8 Displacement of acoustic markers from frame to frame. Green dots represent the initial position and red the final position of the speckles.

European Heart Journal – Cardiovascular Imaging (2015) **16**, 1–11
doi:10.1093/ehjci/jeu184

EUROPEAN SOCIETY OF CARDIOLOGY

CONSENSUS PAPER

Definitions for a common standard for 2D speckle tracking echocardiography: consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging

Jens-Uwe Voigt[1†], Gianni Pedrizzetti[2,3†], Peter Lysyansky[4†], Tom H. Marwick[5], Helen Houle[6], Rolf Baumann[7], Stefano Pedri[8], Yasuhiro Ito[9], Yasuhiko Abe[10], Stephen Metz[11], Joo Hyun Song[12], Jamie Hamilton[13], Partho P. Sengupta[3], Theodore J. Kolias[14], Jan d'Hooge[1], Gerard P. Aurigemma[15], James D. Thomas[16‡], and Luigi Paolo Badano[17‡*]

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Sherif F. Nagueh, Chair, MD, FASE,[1] Otto A. Smiseth, Co-Chair, MD, PhD,[2] Christopher P. Appleton, MD,[1] Benjamin F. Byrd, III, MD, FASE,[1] Hisham Dokainish, MD, FASE,[1] Thor Edvardsen, MD, PhD,[2] Frank A. Flachskampf, MD, PhD, FESC,[2] Thierry C. Gillebert, MD, PhD, FESC,[2] Allan L. Klein, MD, FASE,[1] Patrizio Lancellotti, MD, PhD, FESC,[2] Paolo Marino, MD, FESC,[2] Jae K. Oh, MD,[1] Bogdan Alexandru Popescu, MD, PhD, FESC, FASE,[2] and Alan D. Waggoner, MHS, RDCS[1], *Houston, Texas; Oslo, Norway; Phoenix, Arizona; Nashville, Tennessee; Hamilton, Ontario, Canada; Uppsala, Sweden; Ghent and Liège, Belgium; Cleveland, Ohio; Novara, Italy; Rochester, Minnesota; Bucharest, Romania; and St. Louis, Missouri*

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

Keywords: Diastole, Echocardiography, Doppler, Heart failure

ESC European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2018) **19**, 591–600
doi:10.1093/ehjci/jey042

EACVI CONSENSUS DOCUMENT

Standardization of left atrial, right ventricular, and right atrial deformation imaging using two-dimensional speckle tracking echocardiography: a consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging

Luigi P. Badano[1*†], Theodore J. Kolias[2†], Denisa Muraru[1], Theodore P. Abraham[3], Gerard Aurigemma[4], Thor Edvardsen[5], Jan D'Hooge[6], Erwan Donal[7], Alan G. Fraser[8], Thomas Marwick[9,10], Luc Mertens[11], Bogdan A. Popescu[12], Partho P. Sengupta[13], Patrizio Lancellotti[14,15], James D. Thomas[16], and Jens-Uwe Voigt[17]

STATE-OF-THE-ART REVIEW

Pathophysiology and Echocardiographic Diagnosis of Left Ventricular Diastolic Dysfunction

Check for updates

Jeffrey J. Silbiger, MD, *New York, New York*

Echocardiography is the primary imaging modality used for the clinical evaluation of left ventricular (LV) diastolic function. Using two-dimensional together with transmitral, mitral annular, and pulmonary venous Doppler data, conclusions may be drawn regarding the relaxation and compliance properties of the ventricle that can be used for estimating LV filling pressure. Echocardiographic estimation of LV filling pressure has been shown to be especially useful for evaluating patients with dyspnea of unknown etiology as well as those with heart failure with preserved ejection fraction. Moreover, echocardiographic estimation of LV filling pressure can be used for clinical decision making on day-to-day basis. This article discusses the pathophysiology of diastolic dysfunction and provides a comprehensive review of its echocardiographic evaluation. (J Am Soc Echocardiogr 2019;32:216-32.)

Keywords: Diastolic function, Heart failure, HFpEF, Left ventricular filling pressure

ESC
European Society of Cardiology

European Heart Journal (2021) **42**, 3599–3726
doi:10.1093/eurheartj/ehab368

ESC GUIDELINES

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Developed by the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)

With the special contribution of the Heart Failure Association (HFA) of the ESC

ESC European Society of Cardiology

European Heart Journal - Cardiovascular Imaging (2021) 00, 1–28
doi:10.1093/ehjci/jeab154

EACVI DOCUMENT

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

Otto A. Smiseth (Chair)[1,2,3*], Daniel A. Morris[4], Nuno Cardim[5], Maja Cikes[6], Victoria Delgado[7], Erwan Donal[8,9], Frank A. Flachskampf[10], Maurizio Galderisi[11,†], Bernhard L. Gerber[12], Alessia Gimelli[13], Allan L. Klein[14], Juhani Knuuti[15], Patrizio Lancellotti[16,17], Julia Mascherbauer[18], Davor Milicic[6], Petar Seferovic[19,20], Scott Solomon[21], Thor Edvardsen[1,2,3], and Bogdan A. Popescu (Co-Chair)[22,*]

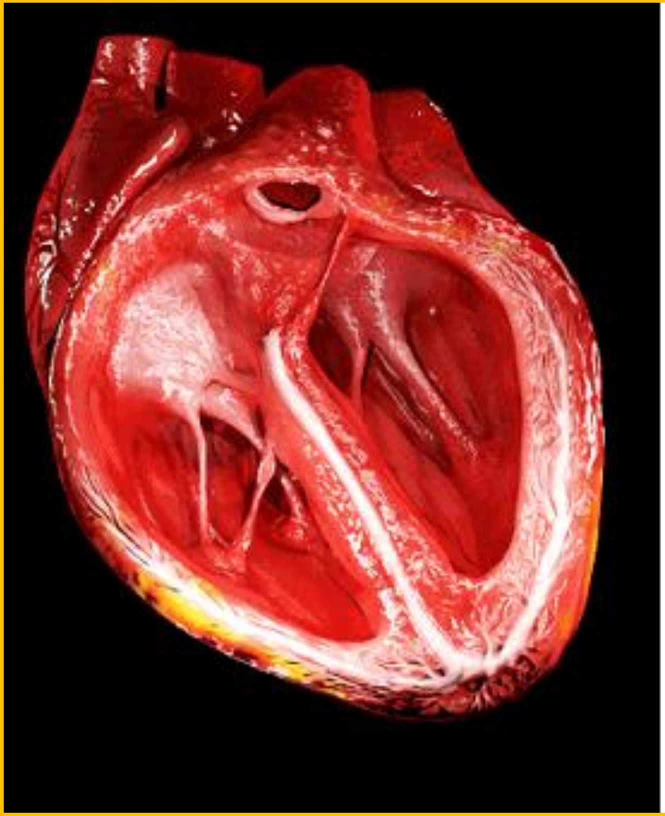
JACC: CARDIOVASCULAR IMAGING

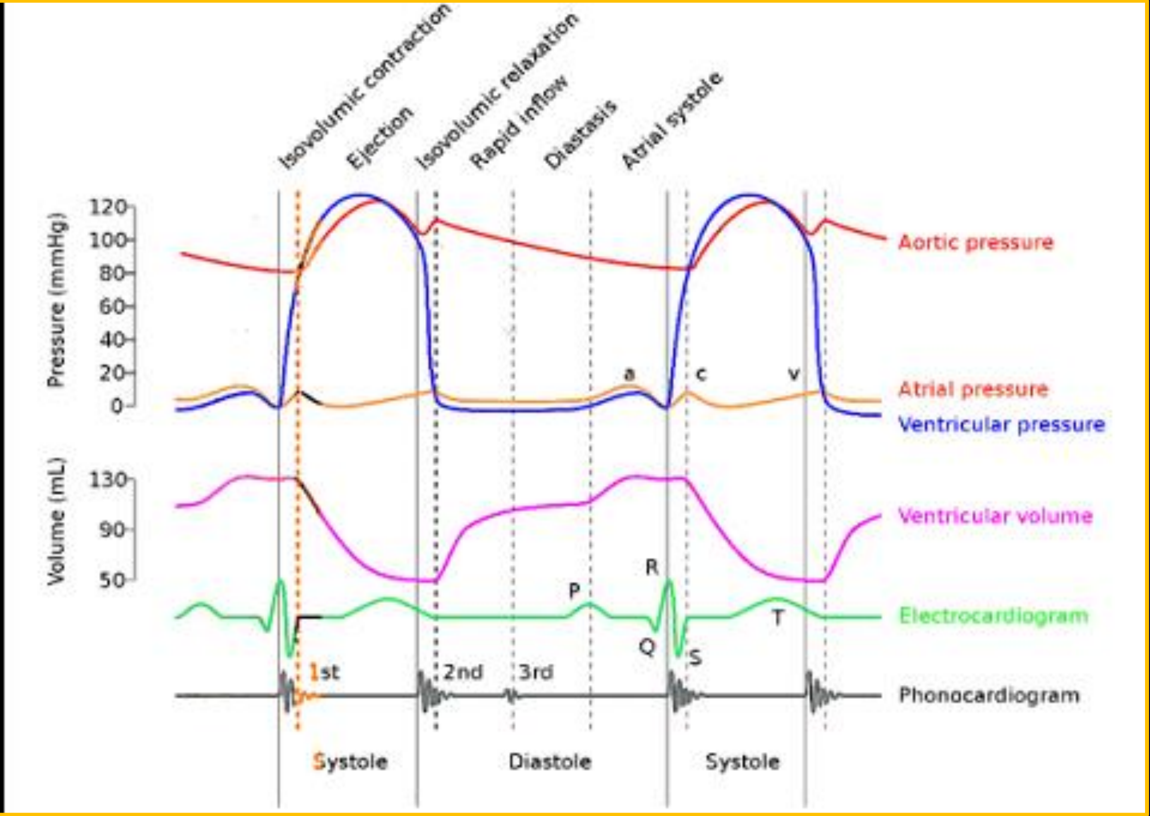
VO

ORIGINAL RESEARCH

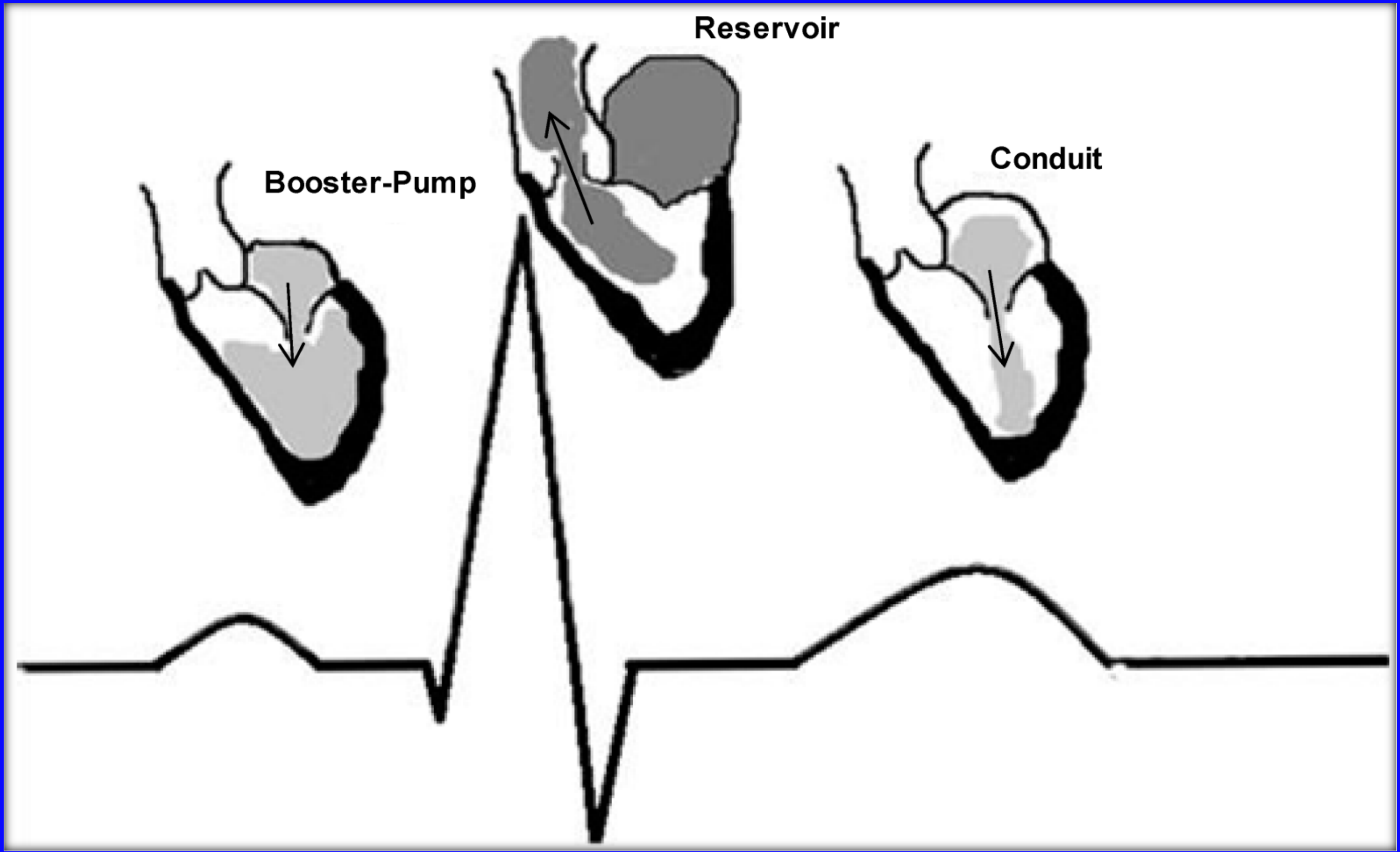
Left Atrial Strain Determinants During the Cardiac Phases

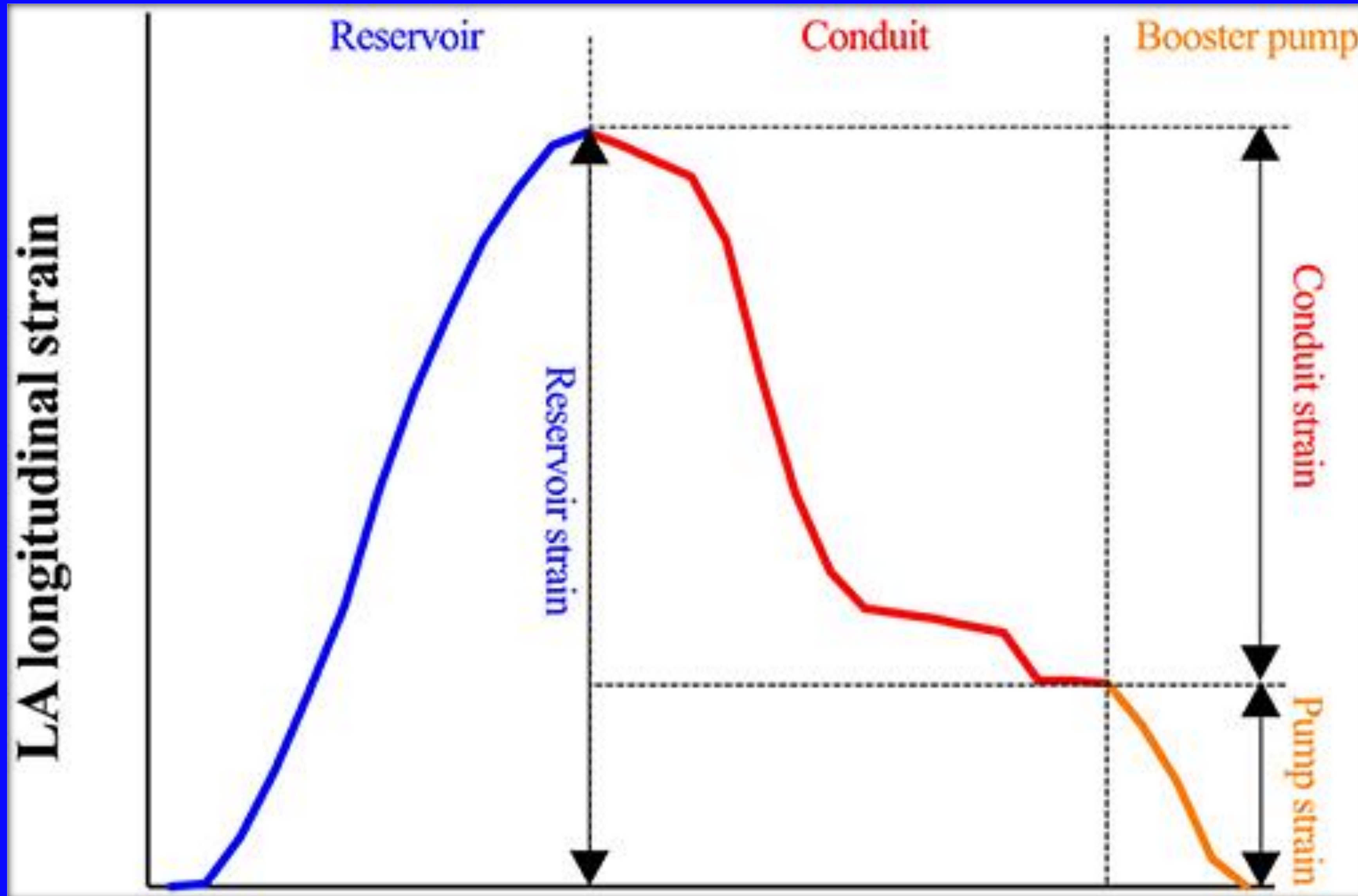
Georgiana-Grațiela Mălăescu, MD,[a,*,†] Oana Mirea, MD, PhD,[a,*,‡] Răzvan Capotă, MD,[a,§]
Aniela Monica Petrescu, MD,[a,||] Jürgen Duchenne, PhD, MSc,[a] Jens-Uwe Voigt, MD, PhD[a,b]

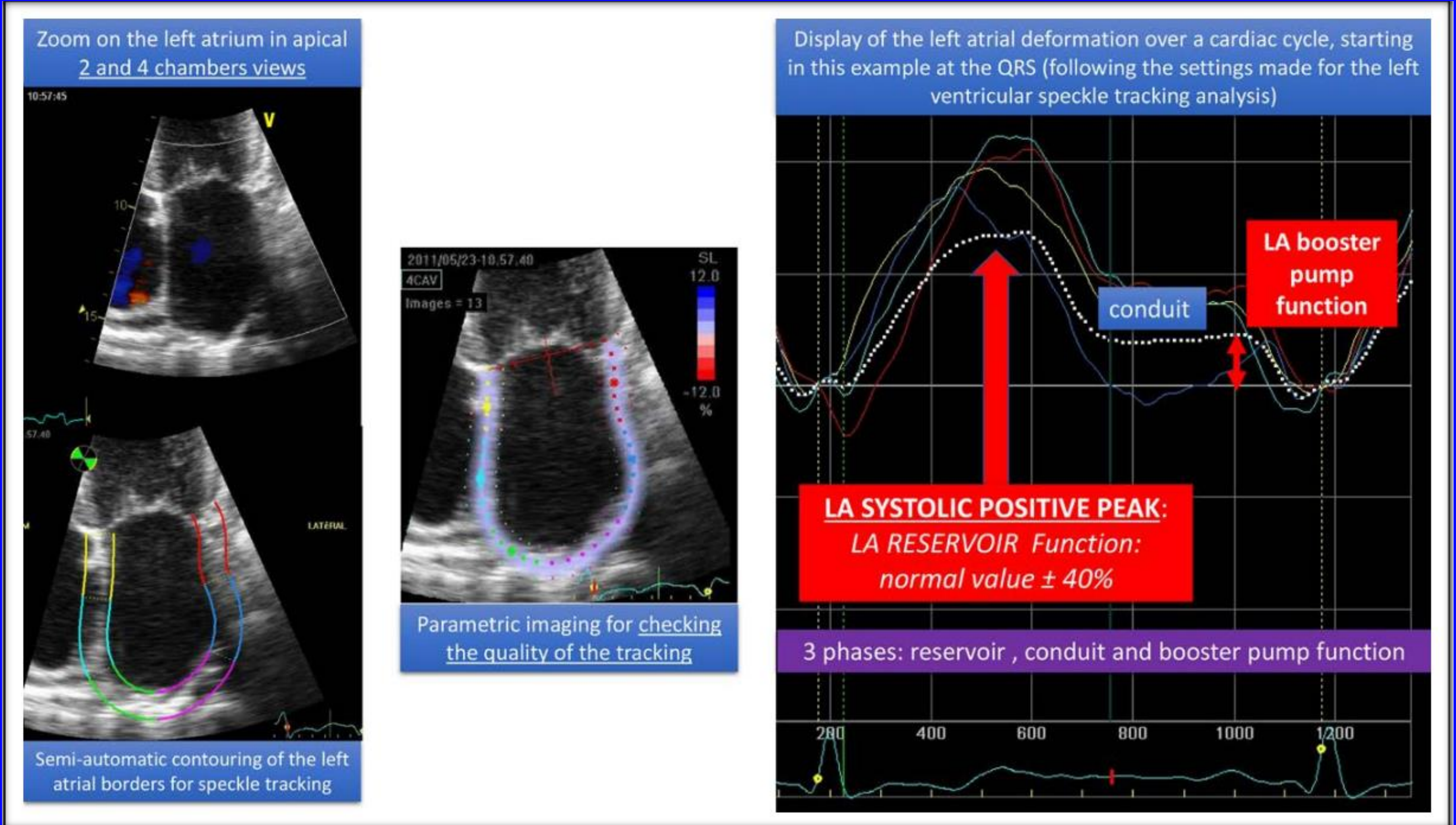


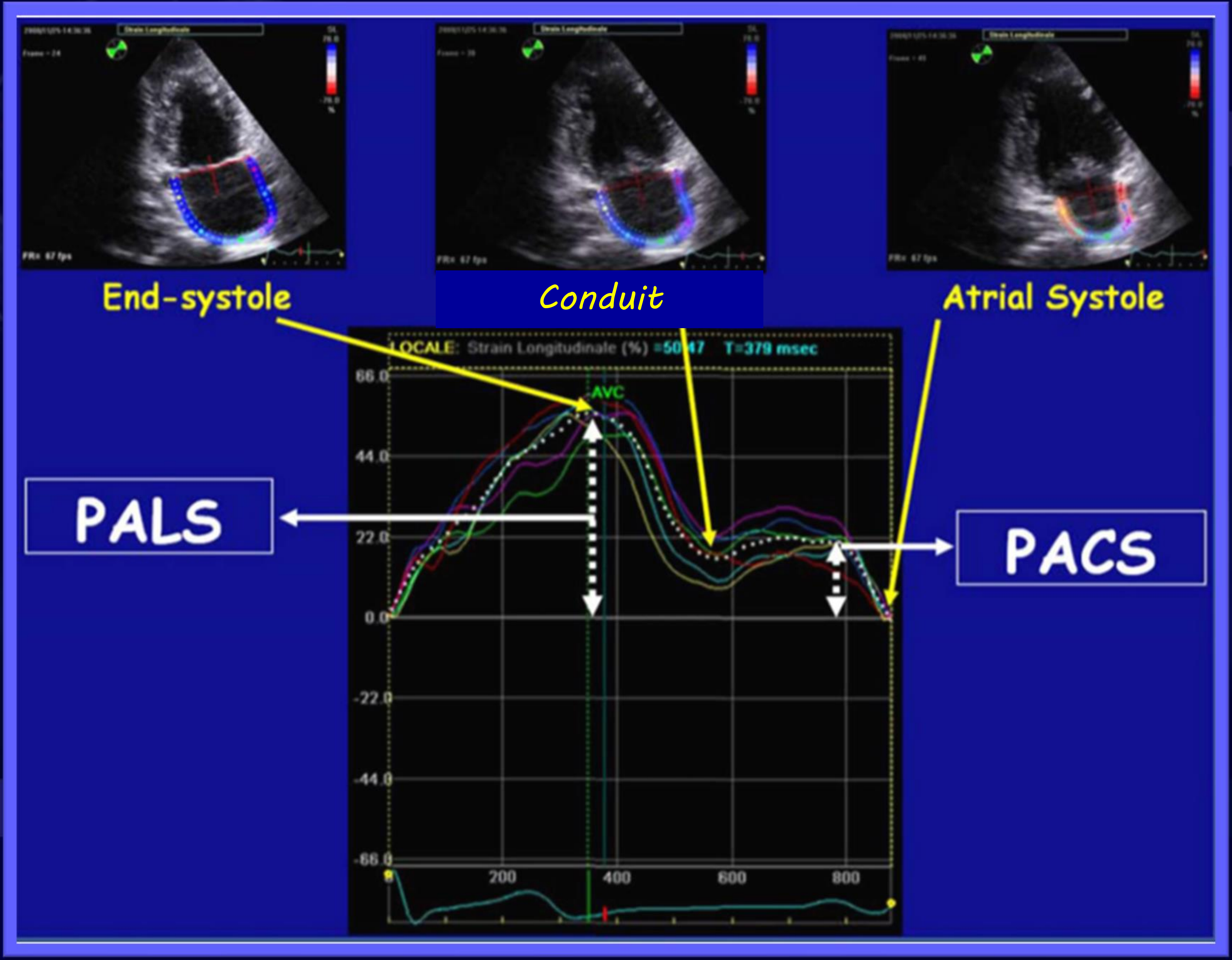


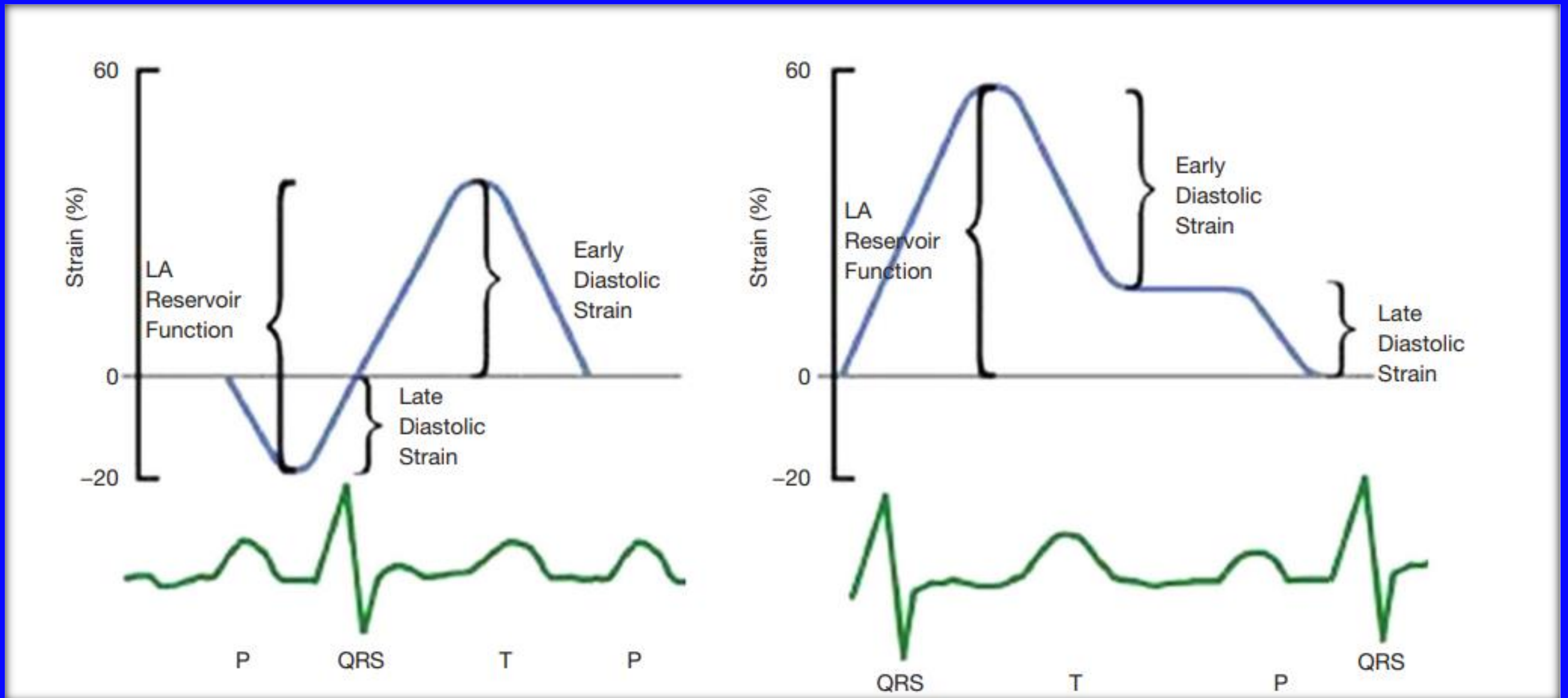
Isovolumic contraction
Ejection
Isovolumic relaxation
Rapid inflow
Diastasis
Atrial systole
Pressure (mmHg)
120
100
80
60
40
20
0
Aortic pressure
a
c
v
Atrial pressure
Ventricular pressure
Volume (mL)
130
90
50
Ventricular volume
R
P
T
Q
S
Electrocardiogram
1st
2nd
3rd
Phonocardiogram
Systole
Diastole
Systole


Reservoir
Booster-Pump
Conduit

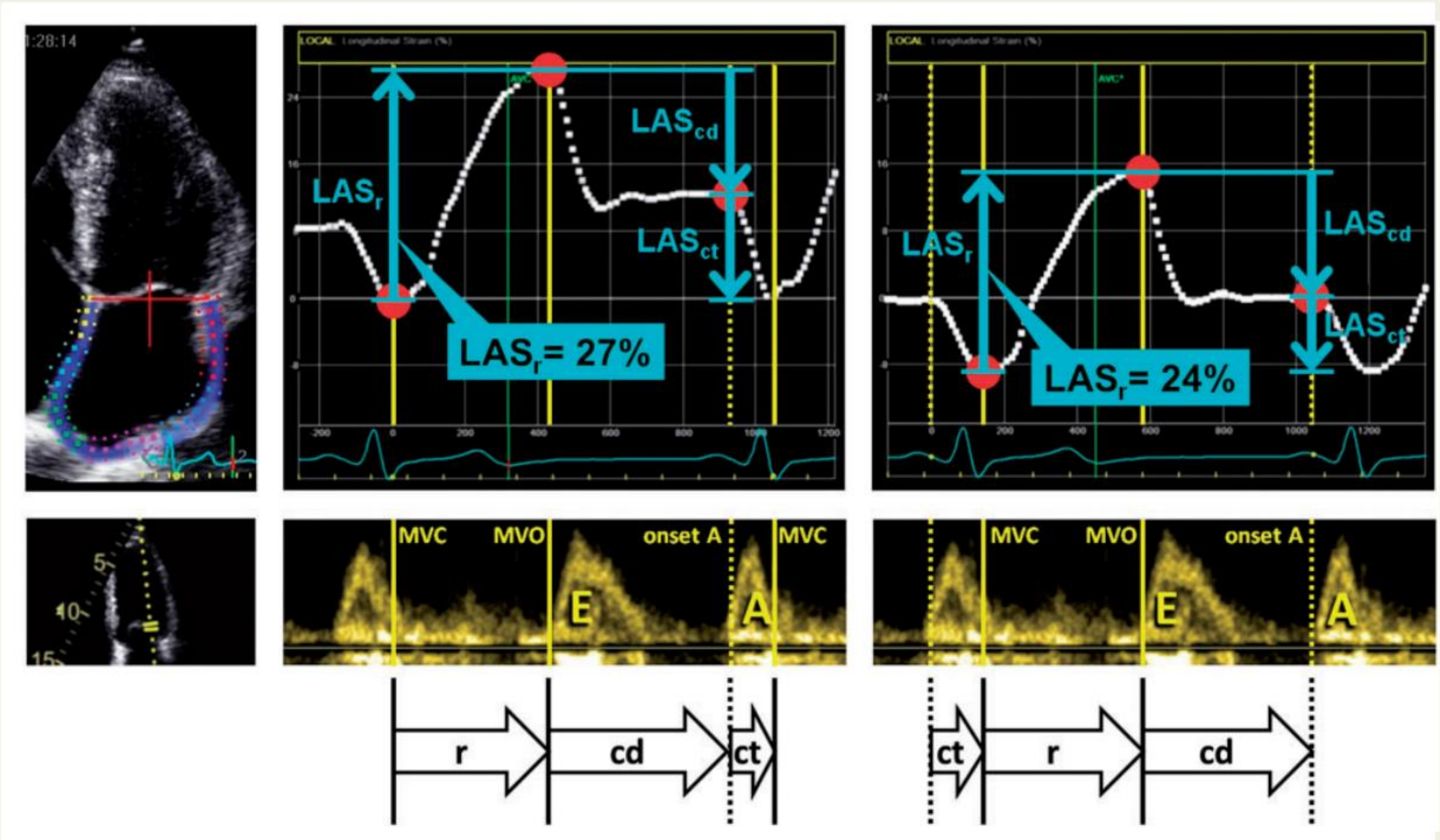

Reservoir
Conduit
Booster pump
LA longitudinal strain
Reservoir strain
Conduit strain
Pump strain


Zoom on the left atrium in apical 2 and 4 chambers views
10:57:45
V
10
15
LATERAL
Semi-automatic contouring of the left atrial borders for speckle tracking
2011/05/23-10:57:40
4CAV
Images = 13
SL
12.0
-12.0
%
Parametric imaging for checking the quality of the tracking
Display of the left atrial deformation over a cardiac cycle, starting in this example at the QRS (following the settings made for the left ventricular speckle tracking analysis)
LA booster pump function
conduit
LA SYSTOLIC POSITIVE PEAK:
LA RESERVOIR Function:
normal value ± 40%
3 phases: reservoir , conduit and booster pump function
200
400
600
800
1000
1200

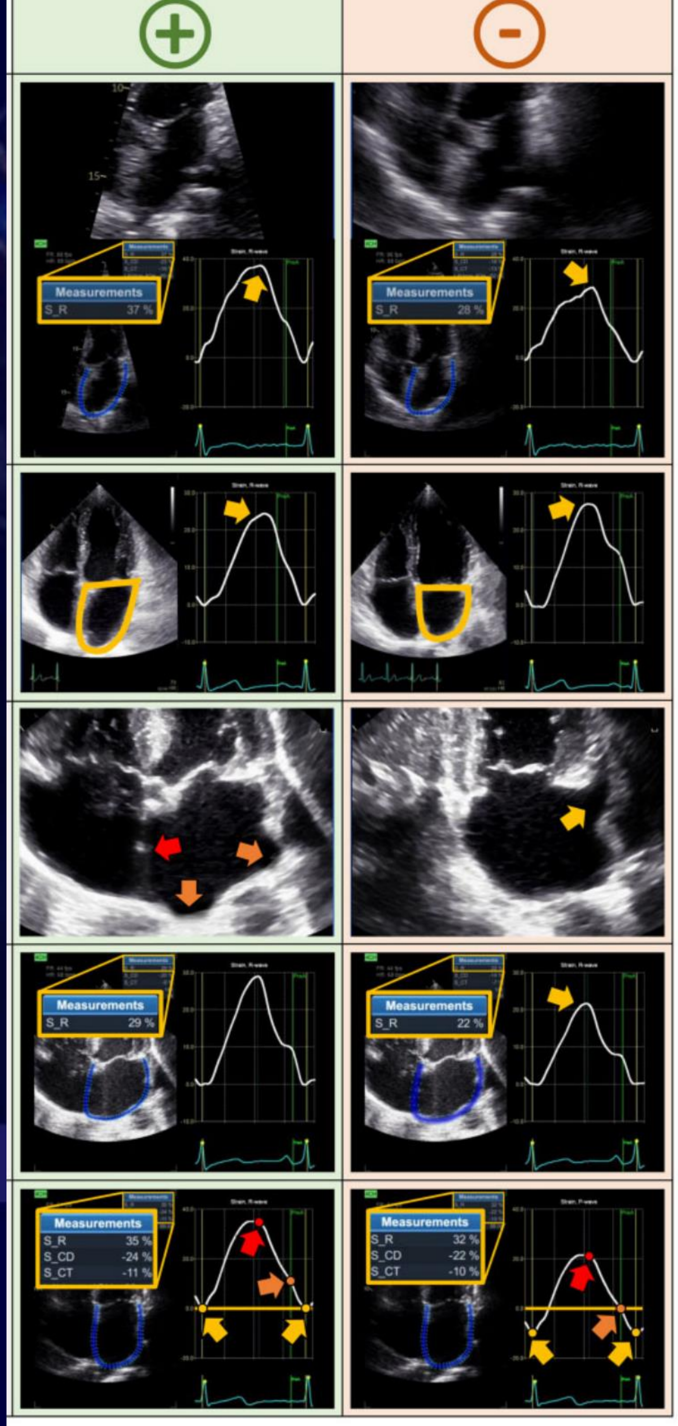

End-systole
Conduit
Atrial Systole
PALS
PACS
LOCALE: Strain Longitudinale (%)
T=379 msec
AVC
66.0
44.0
22.0
0.0
-22.0
-44.0
-66.0
200
400
600
800



60
Strain (%)
LA
Reservoir
Function
Early
Diastolic
Strain
0
Late
Diastolic
Strain
–20
P
QRS
T
P
60
Strain (%)
LA
Reservoir
Function
Early
Diastolic
Strain
Late
Diastolic
Strain
0
–20
QRS
T
P
QRS



LAS_cd
LAS_r
LAS_ct
LAS_r = 27%
LAS_r = 24%
MVC
MVO
onset A
E
A
r
cd
ct



Measurements
S_R 37 %
Measurements
S_R 28 %
Measurements
S_R 29 %
Measurements
S_R 22 %
Measurements
S_R 35 %
S_CD -24 %
S_CT -11 %
Measurements
S_R 32 %
S_CD -22 %
S_CT -10 %

LOCAL: Longitudinal Strain (%) =-48.94
T=430 msec
72.0
-72.0
%
SS=0.0%
LACS
PALS
PACS
60
40
20
0
-20
-40
-60
-200
0
200
400
600
800
1000

JASE 2017

LEFT ATRIAL FUNCTION

Normal Ranges of Left Atrial Strain by Speckle-Tracking Echocardiography: A Systematic Review and Meta-Analysis

Faraz Pathan, MBBS, Nicholas D'Elia, BSc, Mark T. Nolan, MBBS, Thomas H. Marwick, MBBS, PhD, MPH, and Kazuaki Negishi, MD, PhD, *Hobart and Melbourne, Australia*

LA Strain: normal range (meta-analysis)

- 40 studies
- 36 with single vendor
- 37 R-R gating; 3 P-P gating

- Reservoir: 39.4% (38%-41%)

- Conduit: 23% (21%- 25%)

- Contractile function: 17.4% (16%-19%)

- HR; Gender and BSA contribute to heterogenicity

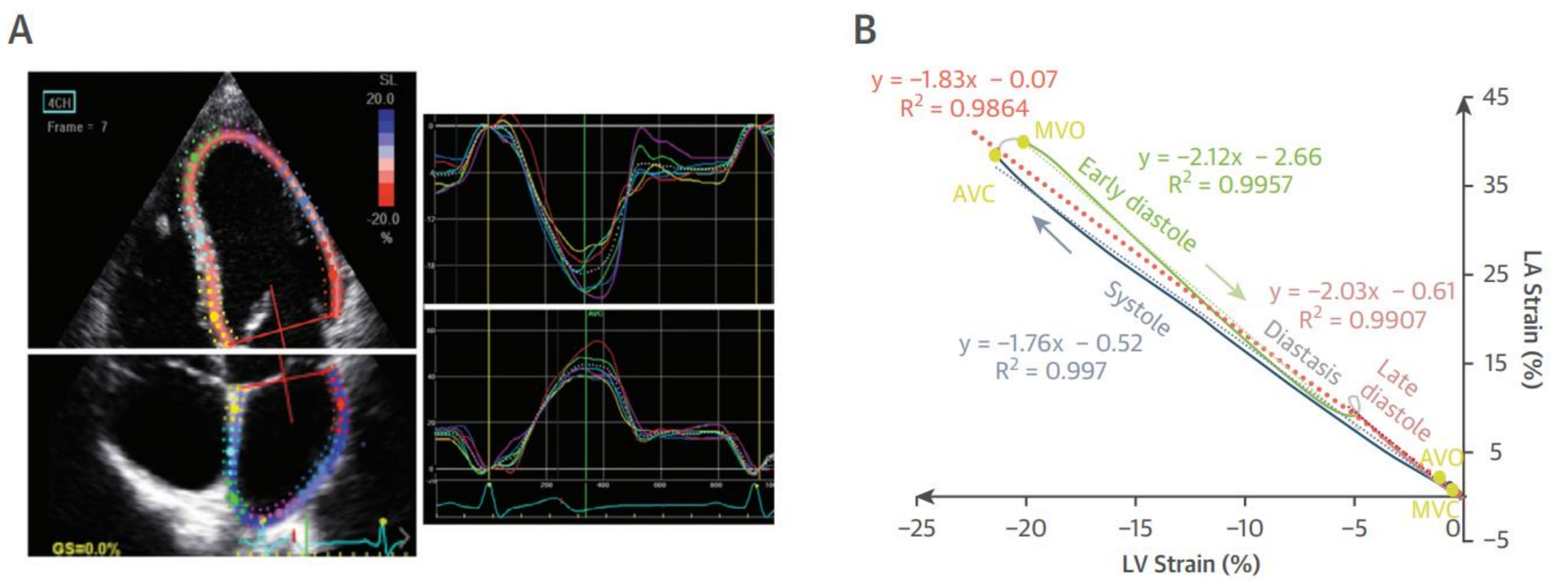
Table 2 Summary of normal ranges of LA strain components

LA strain component	Number of studies	Mean	95% CI	Cochrane Q	I^2	τ^2
Reservoir	40	39.4	38.0–40.8	1,653 ($P < .001$)	97.6	20.0
Conduit	14	23.0	20.7–25.2	420 ($P < .001$)	96.9	17.9
Contractile	18	17.4	16.0–19.0	631 ($P < .001$)	97.3	9.7

Use of LA Strain

LA- LV

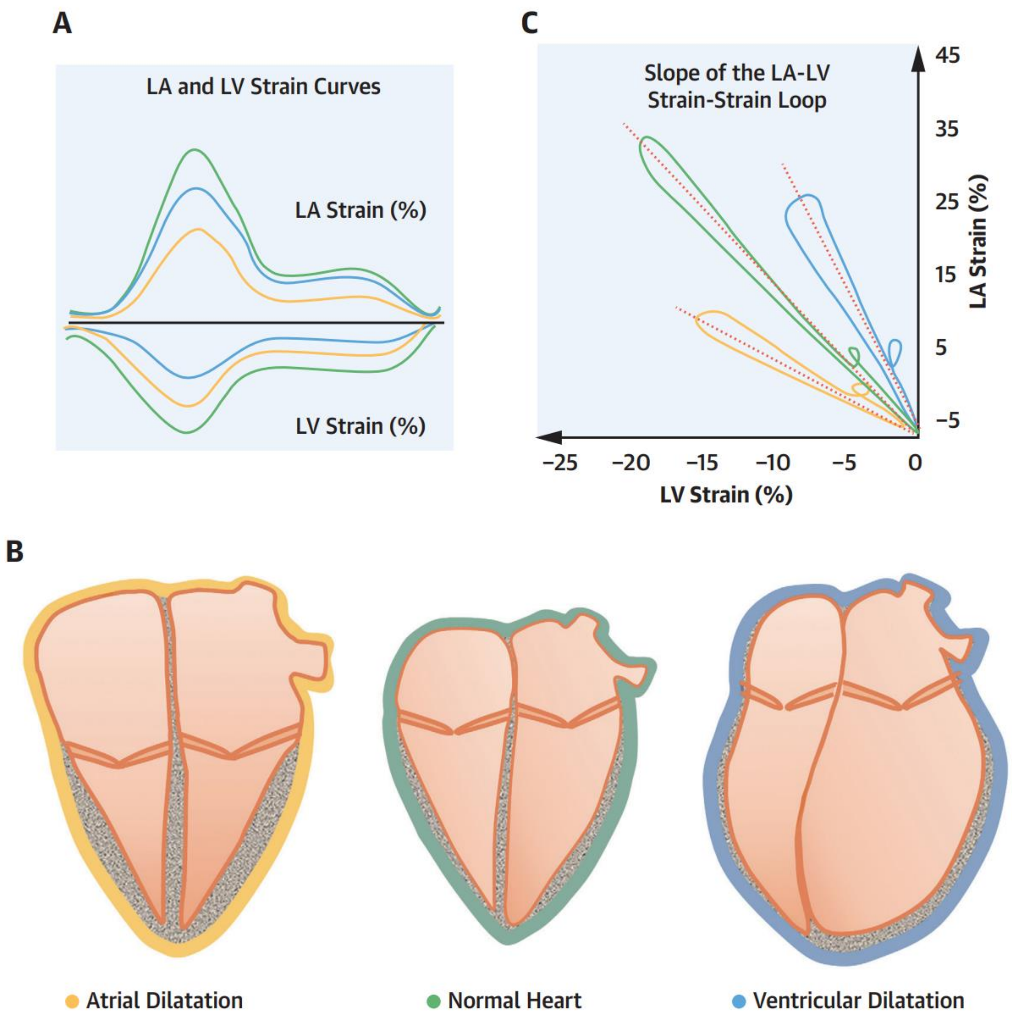
FIGURE 1 Representative Example of LV and LA Strain Tracking and Strain-Strain-Loop



(A) 2D speckle tracking of the left ventricle (LV) and left atrium (LA) in 4-chamber view. **(B)** Reconstruction of an LA-LV strain-strain loop and the corresponding regression lines for the entire loop **(red dotted line)** and per phase of the cardiac cycle (**blue** = systole, **green** = early diastole, and **brown** = late diastole). Note that each regression line has a slope and an R^2. **Yellow dots** indicate aortic and mitral valve opening and closure (AVO, AVC, MVO, MVC). AVC = aortic valve closed; AVO = aortic valve open; MVC = mitral valve closed; MVO = mitral valve open.

Voigt et al JACC CV Img 2022

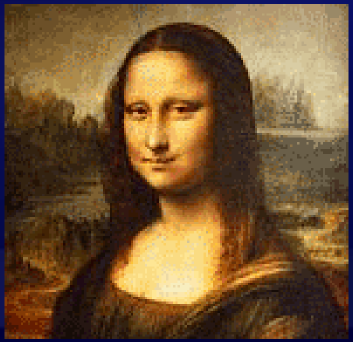
CENTRAL ILLUSTRATION **Left Atrial and Left Ventricular Strain Curves and the Respective Strain-Strain Loops in 3 Clinical Scenarios**



Mălăescu, G.-Grațiela et al. J Am Coll Cardiol Img. 2022;15(3):381-391.

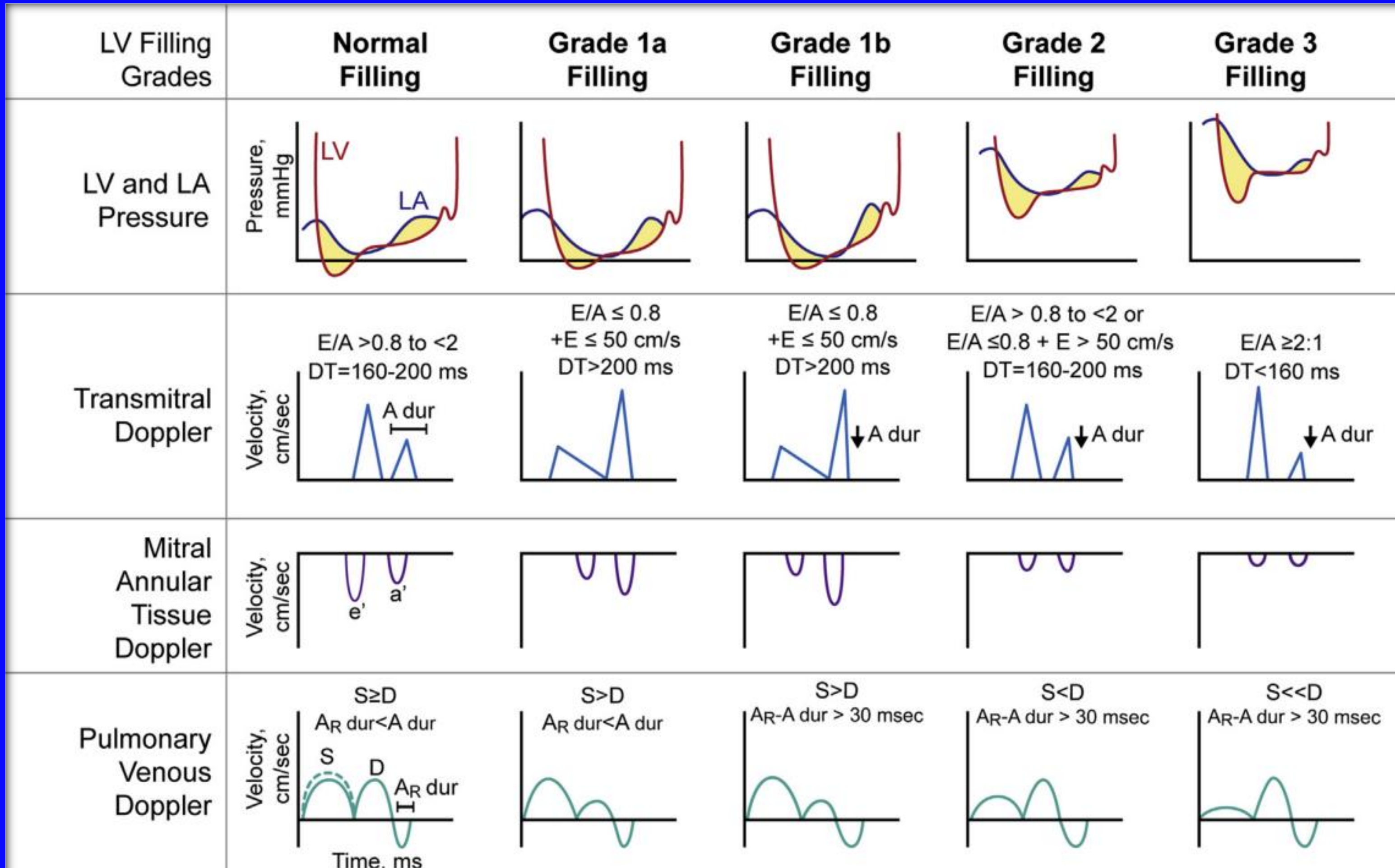
(A) Left atrial (LA) and left ventricular (LV) strain curves are obtained in 3 categories of patients. **(B) Yellow** = atrial dilatation; **green** = normal heart; **blue** = ventricular dilatation. **(C)** LA-LV strain-strain loops were reconstructed for each patient. Note the differing slopes **(dotted red lines)** of the LA-LV strain loops, reflecting the LV/LA volume relation.

Diastolic Dysfunction



Diastolic Dysfunction

- Multiple determinants
- Difficult to measure
- Diagnosis by exclusion
- Nonspecific treatment



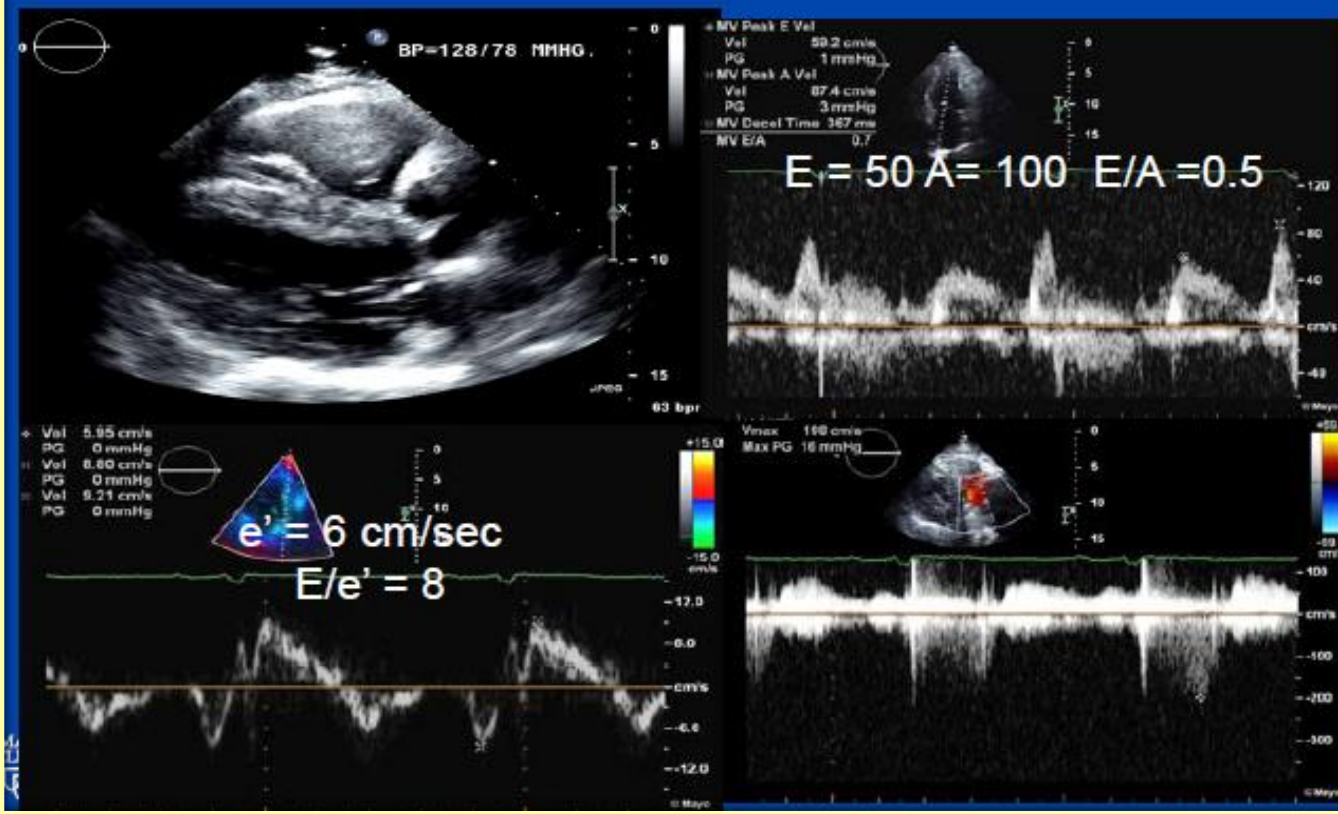
LV Filling Grades	Normal Filling	Grade 1a Filling	Grade 1b Filling	Grade 2 Filling	Grade 3 Filling
LV Relaxation	Normal	Decreased	Decreased	Decreased	Decreased
LV Compliance	Normal	Normal	↓	↓↓	↓↓↓
/ Filling Pressure	Normal	Normal	↑LVEDP	↑Mean LAP	↑↑Mean LAP
LA Volume	Normal	Normal	Normal	↑	↑↑

Characteristic hemodynamic pressure and Doppler echocardiographic findings seen with different LV filling patterns.

Grade and Filling Pressure are not independent of one another

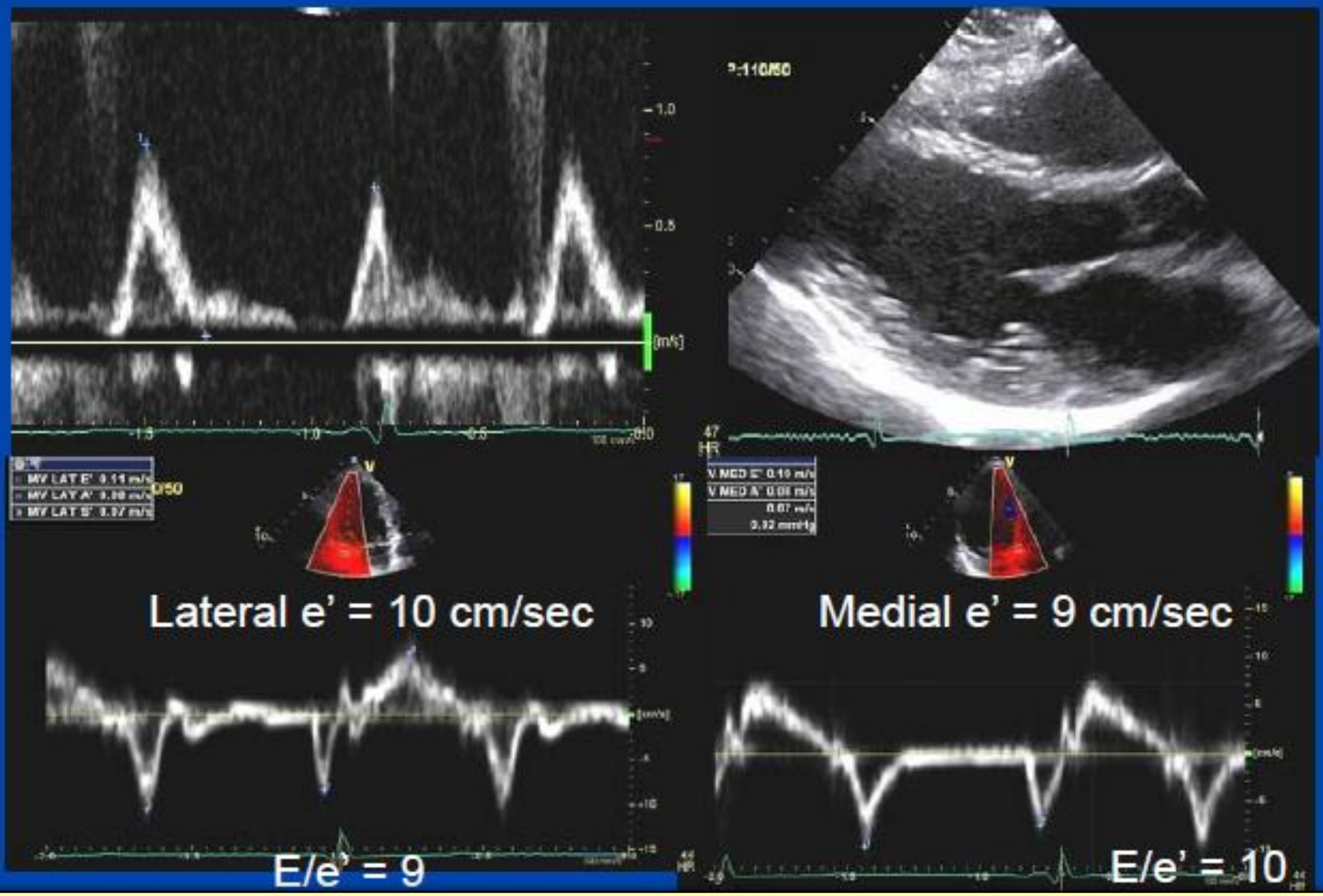
Grade	Filling Pressure	
Normal	Normal	
1	Normal	High
2		High
3		High

Normal or Grade 1 Diastolic Dysfunction ?
LAVI 28 mL/m²



E/e' NL < 14
e' ABNL < 7
LAVI Normal
TR NL < 2.8

71 year old woman with LAVI = 39 mL/m^2



E/e'	NL	< 14
e'	NL	> 7
LAVI	Enlarged	
TR	NL	< 2.8

Assessment of Pressure

Left Atrial Volume

LA Size

Chronic loading

Same size, different pressure

Same pressure, different size

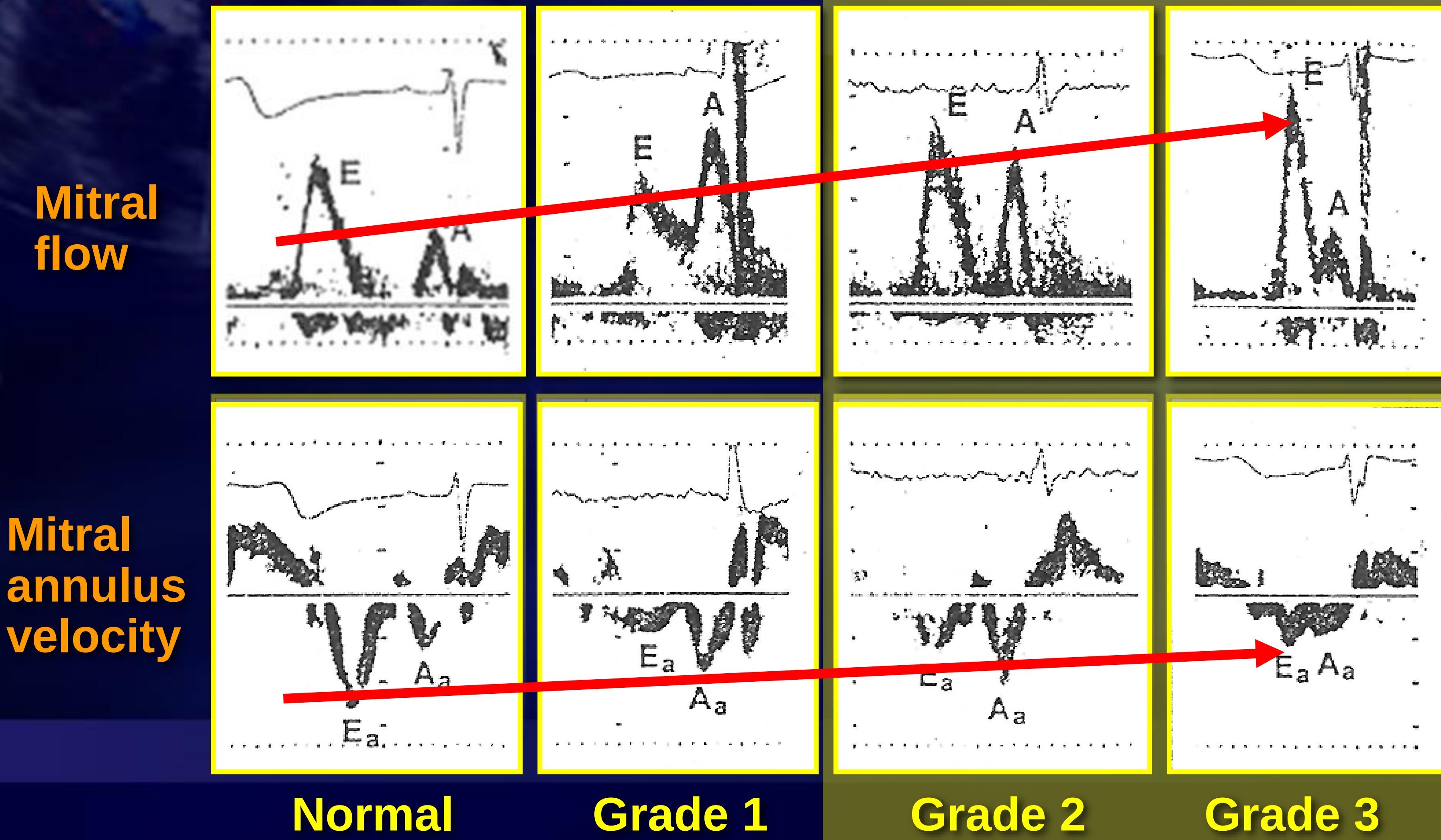
LA normal

There has been no long-term stress or pressure elevation

LA enlarged

There has been adverse load, but you cannot discern current filling pressure without Doppler findings

Tissue Doppler



E/E' Ratio May Not Apply

- Normal heart
- Constrictive pericarditis
- Mitral stenosis or insufficiency
- Mitral or aortic valve replacement
- Mitral annular calcification
- Hypertrophic cardiomyopathy
- Acute decompensated heart failure (CRT)

Estimating LAP in Patients with Diastolic Dysfunction

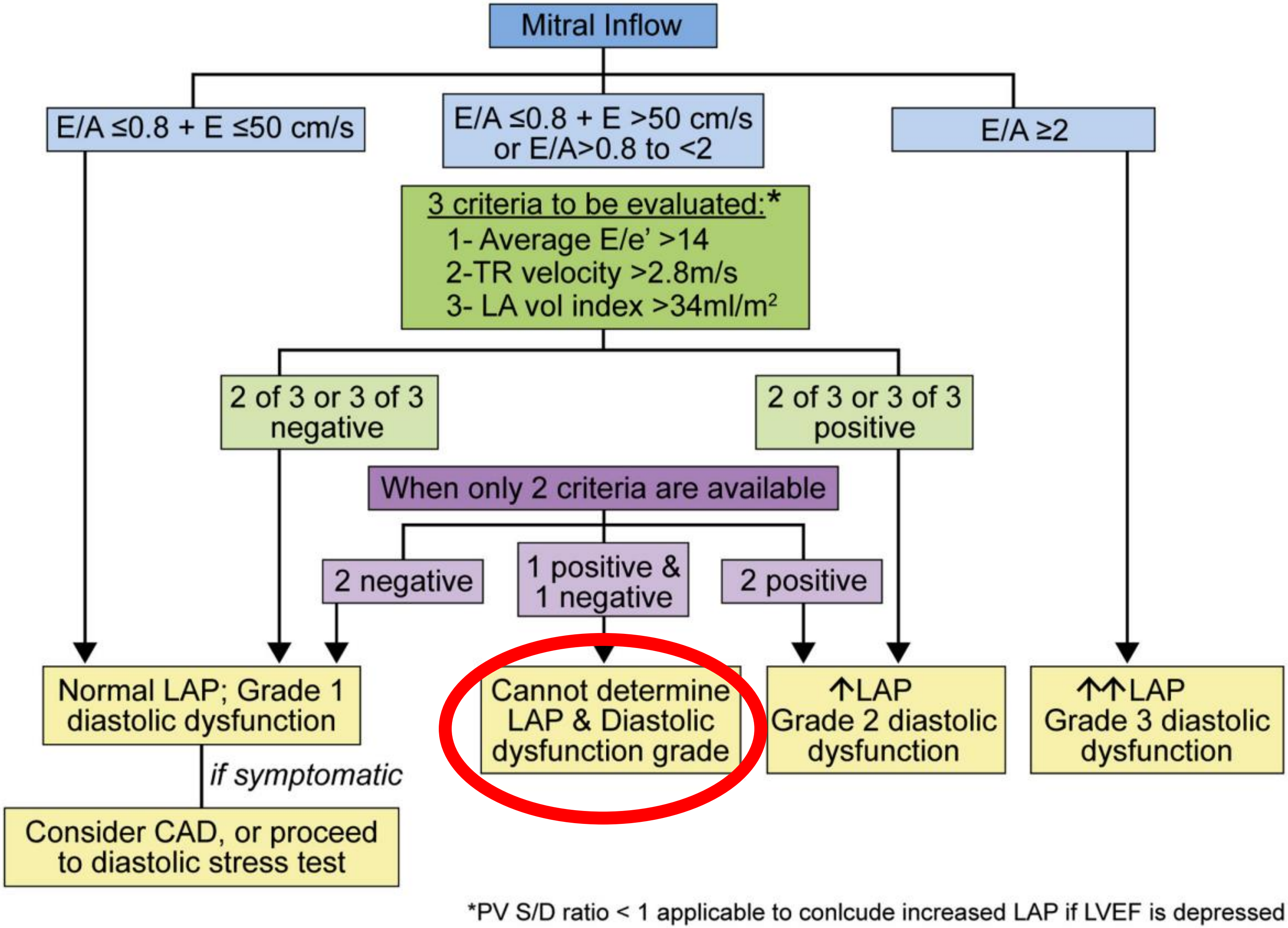


Figure 15 Algorithm for determining LV filling grade and mean LAP in patients with reduced LVEF, LV myocardial disease, or clinical evidence of diastolic dysfunction. See text. Reproduced with permission from Nagueh *et al.*[58]

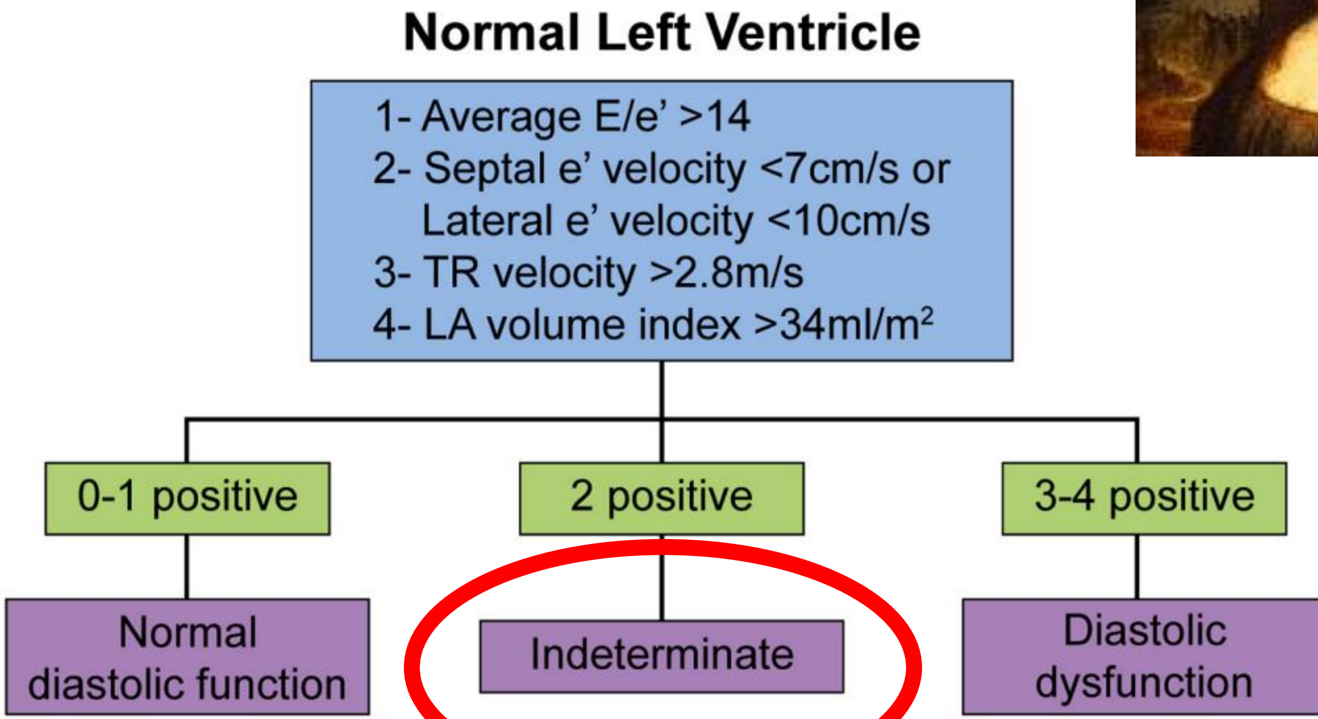


Figure 16 Algorithm for determining if LV diastolic dysfunction is present in patients with normal LVEFs and no evidence of myocardial disease. See text. Reproduced with permission from Nagueh et al.

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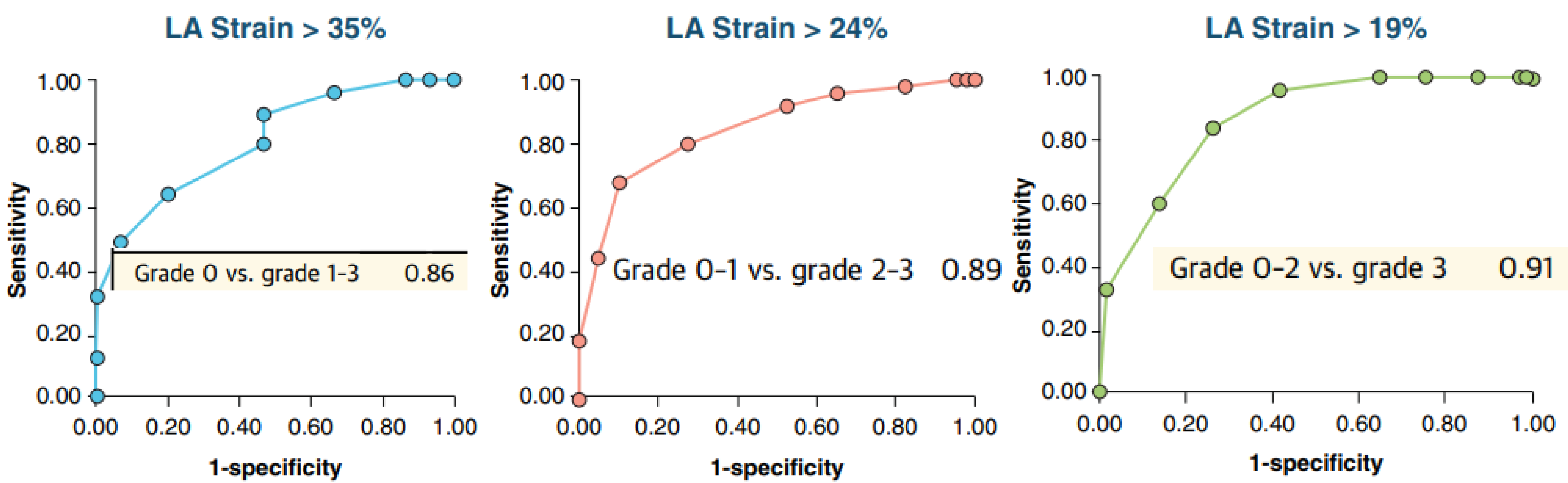
LA Strain for Categorization of LV Diastolic Dysfunction

Amita Singh, MD, Karima Addetia, MD, Francesco Maffessanti, PhD, Victor Mor-Avi, PhD, Roberto M. Lang, MD

FIGURE 5 ROC Curves for LA Strain



Three distinct curves were obtained to differentiate grade 0 from grades 1 to 3 DD **(left)**, grade 0 to 1 DD from grades 2 to 3 DD **(middle)**, and grades 0 to 2 DD from grade 3 DD **(right)**. ROC = receiver-operating characteristic; other abbreviations as in Figures 1 and 2.

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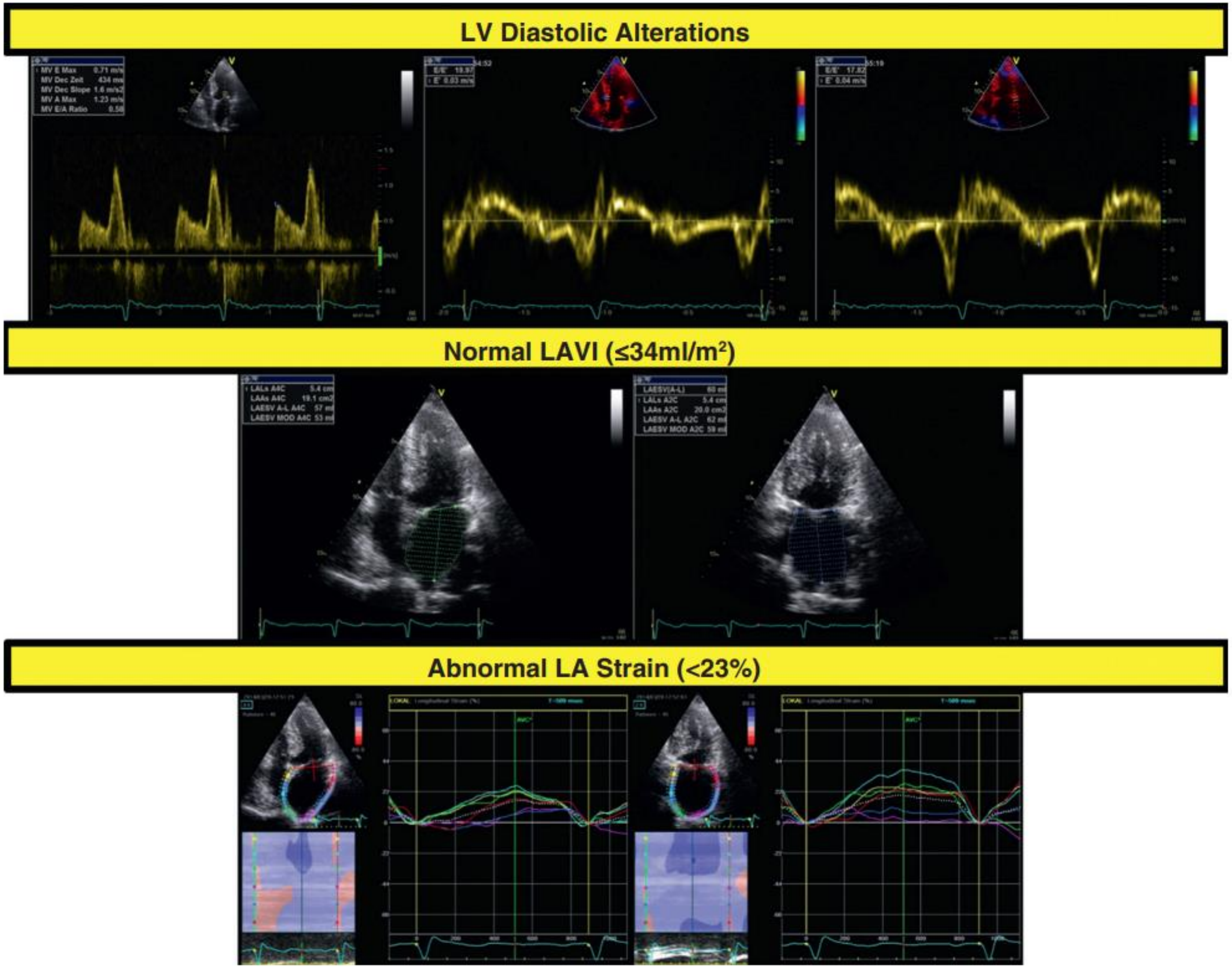
Potential Usefulness and Clinical Relevance of Adding Left Atrial Strain to Left Atrial Volume Index in the Detection of Left Ventricular Diastolic Dysfunction

Daniel A. Morris, MD,[a] Evgeny Belyavskiy, MD,[a] Radhakrishnan Aravind-Kumar, MD,[a] Martin Kropf, MSc,[a] Athanasios Frydas, MD,[a,b] Kerstin Braunauer,[a] Esteban Marquez, MD,[c] Maximilian Krisper, MD,[a] Ruhdja Lindhorst, MD,[a] Engin Osmanoglou, MD,[d] Leif-Hendrik Boldt, MD,[a] Florian Blaschke, MD,[a] Wilhelm Haverkamp, MD,[a] Carsten Tschöpe, MD,[a,b] Frank Edelmann, MD,[a,b,e] Burkert Pieske, MD,[a,b,d,f] Elisabeth Pieske-Kraigher, MD[a]

FIGURE 1 Usefulness of Adding Left Atrial Strain to Maximal Left Atrial Volume Index in the Detection of Left Ventricular Diastolic Alterations



This figure shows a patient with LV diastolic alterations and abnormal LA strain despite normal LAVI. LA strain was determined as the average value of the longitudinal positive strain peak during LA relaxation from all segments of the LA in the apical 4-chamber and 2-chamber views and using the onset of the QRS as the referent point (i.e., analyzing the cardiac cycle between 2 QRS of the ECG). The white curve (with white points) represents the average value of LA strain from all LA segments analyzed in the apical 4-chamber or 2-chamber view. ECG = electrocardiogram; LA = left arterial; LAVI = maximal left arterial volume index; LV = left ventricular.

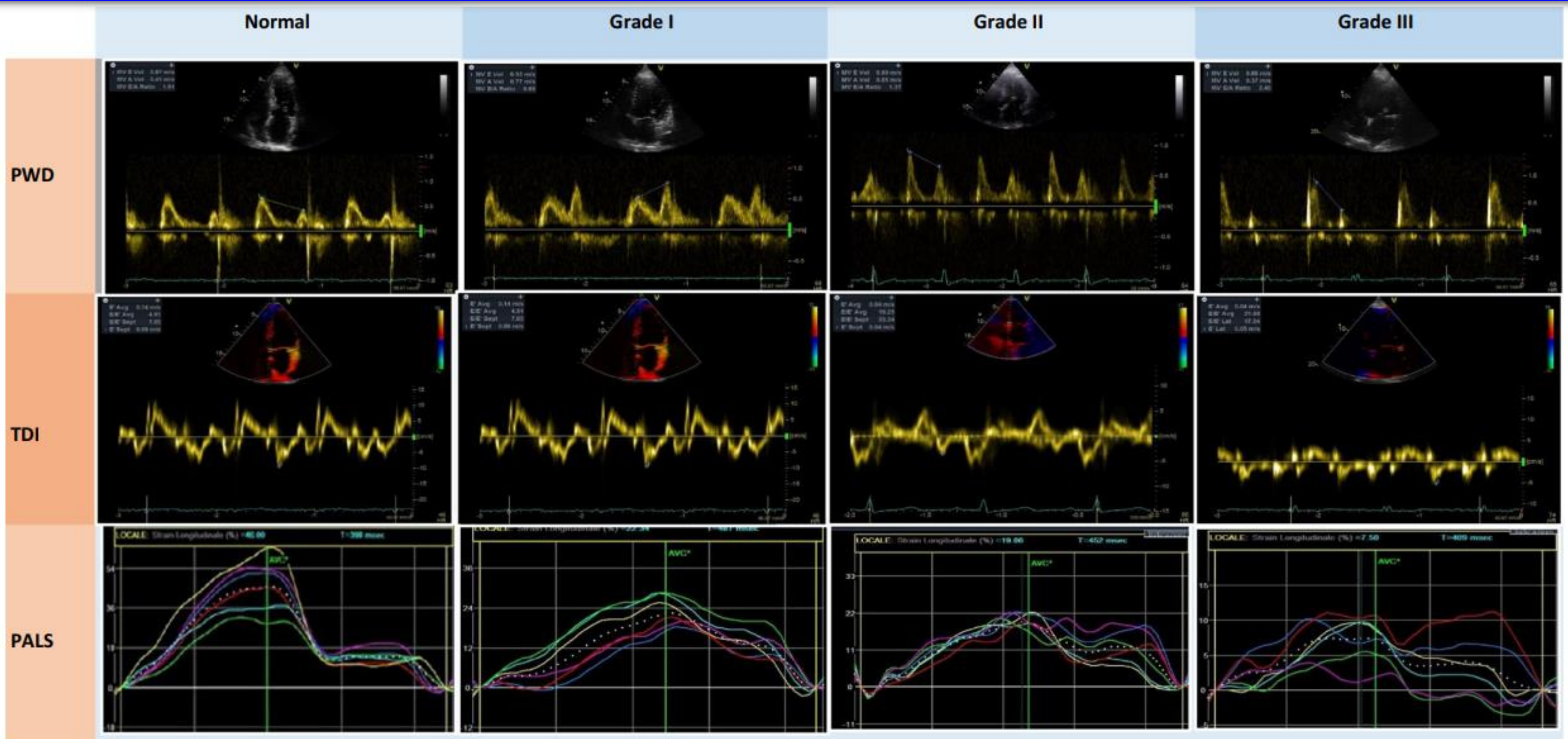
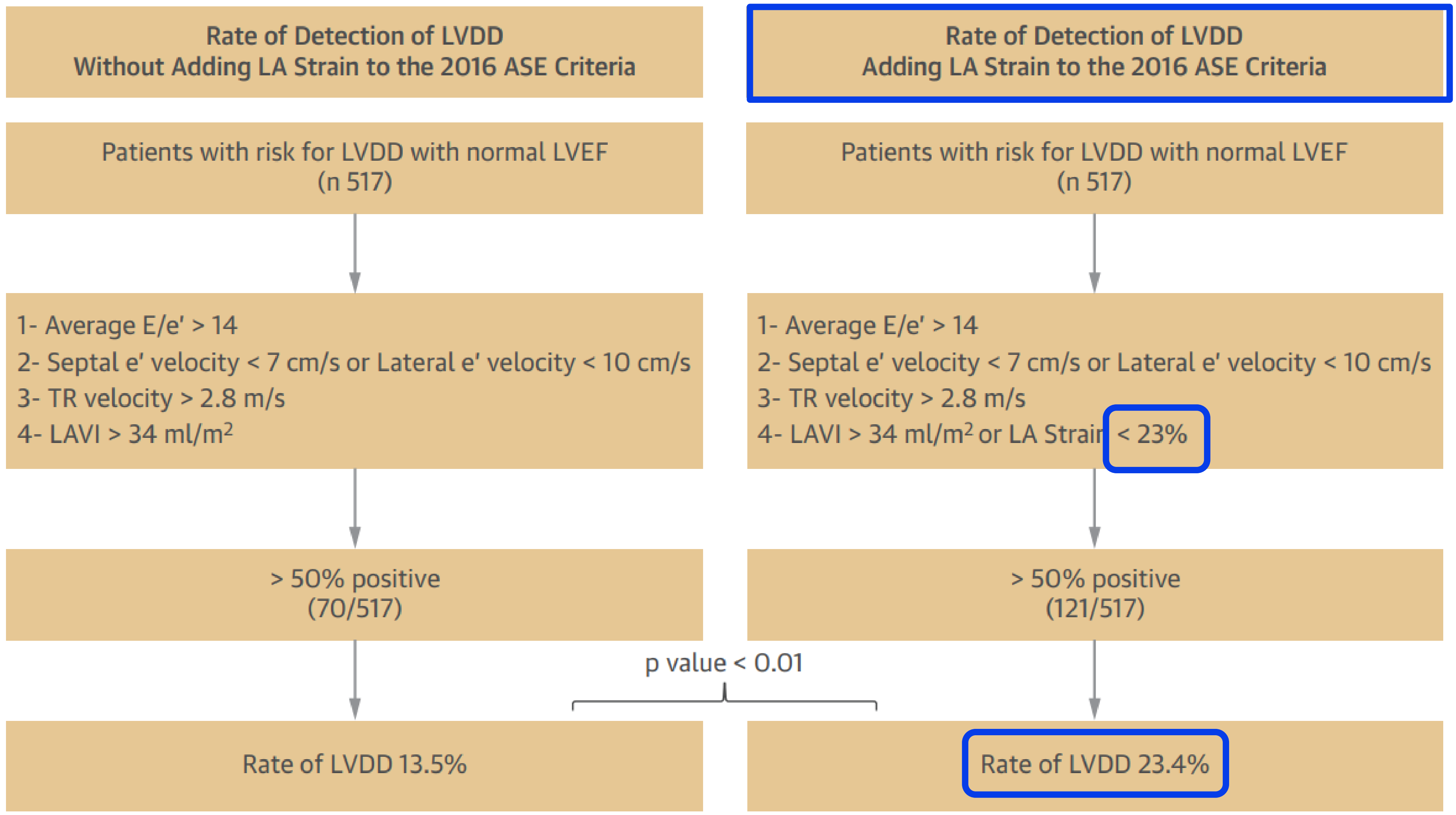


Fig. 2 Modifications of pulsed wave Doppler (PWD) pattern, tissue Doppler imaging (TDI) with E/e' and peak atrial longitudinal strain (PALS) according to diastolic dysfunction (DD) grade. (*Created with Microsoft Office*)

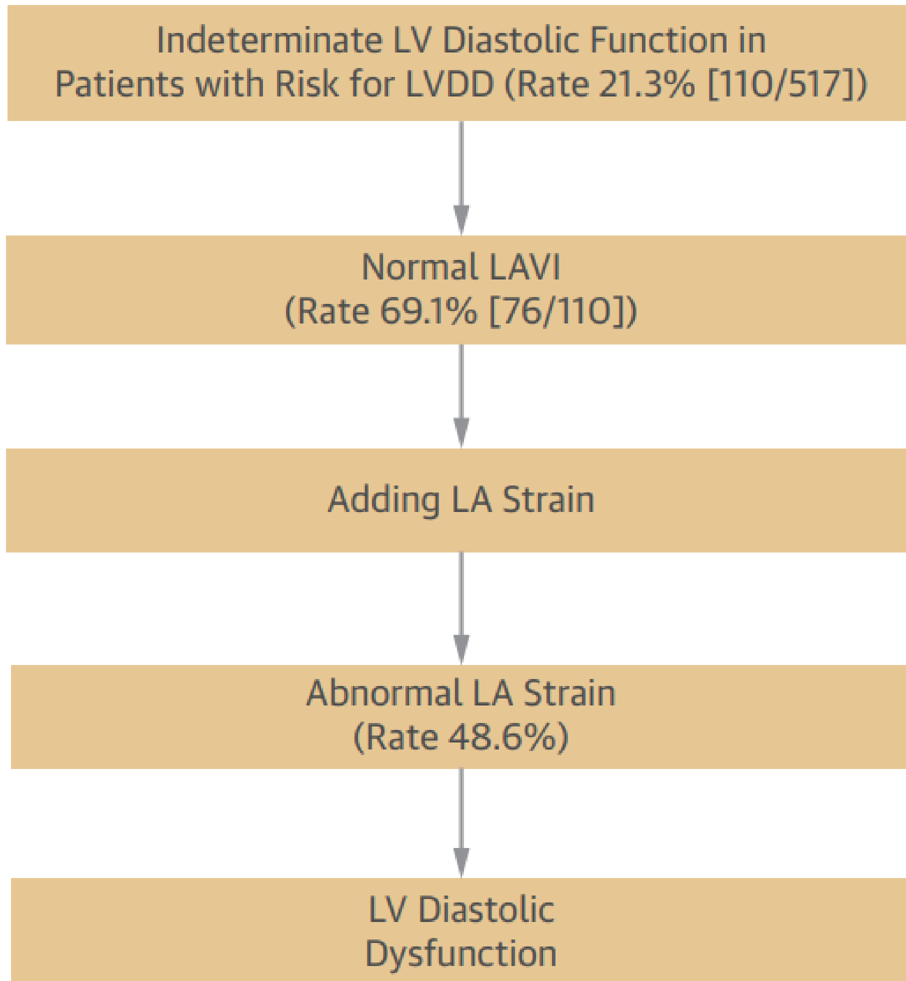
Mandoli et al. Heart Fail Rev (2020) 25:409-417

FIGURE 5 **Potential Usefulness of Adding LA Strain to LAVI in the Detection of LV Diastolic Dysfunction**



Adding LA strain to LAVI in the evaluation of LVDD could help to increase significantly the detection of LVDD. The p value was <0.01 in both the chi-square and the McNemar tests. ASE = American Society of Echocardiography; LVDD = left ventricular diastolic dysfunction; LVEF = left ventricular ejection fraction; TR = tricuspid regurgitation jet peak velocity; other abbreviations as in Figure 1.

FIGURE 6 **Potential Usefulness of LA Strain in the Setting of Indeterminate LV Diastolic Function in Patients With Normal LAVI**



Indeterminate LV diastolic function was defined according to the recent recommendations of the ASE for LVDD. Abbreviations as in Figures 1 and 5.

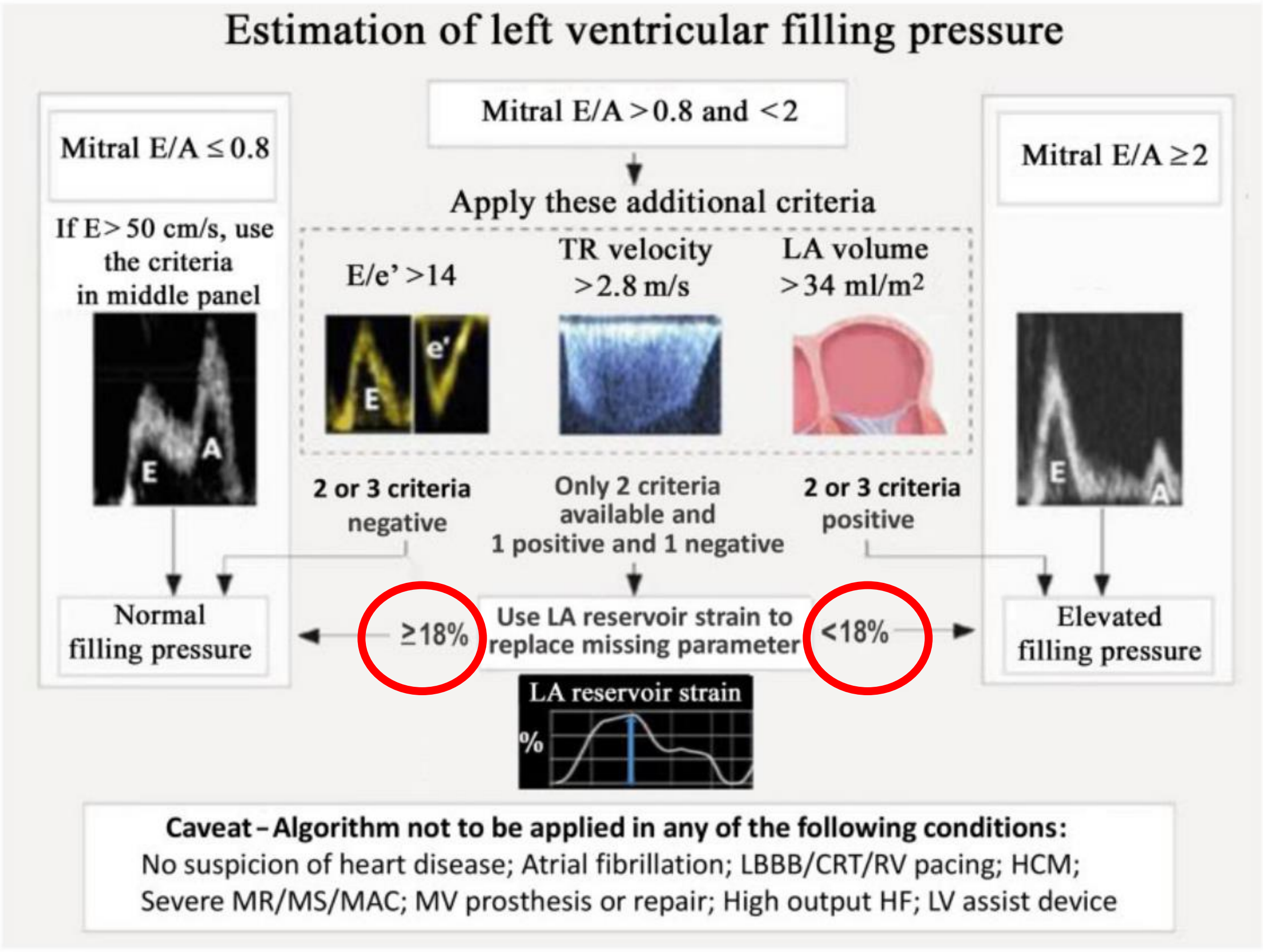
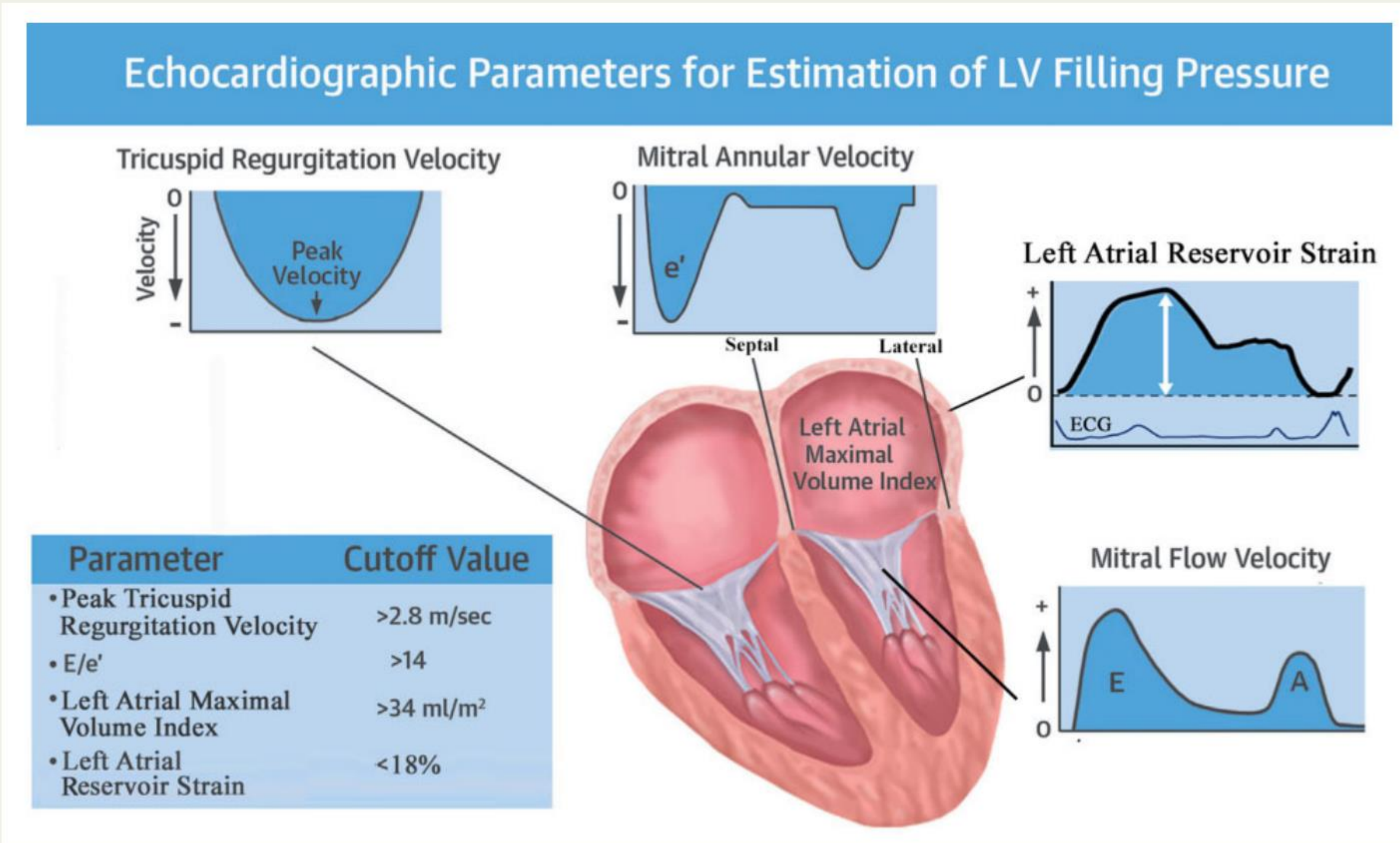


Figure 15 Algorithm for estimation of LV filling pressure.



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%

Figure 13 Echocardiographic parameters for evaluation of LV filling pressure.

Heart Failure

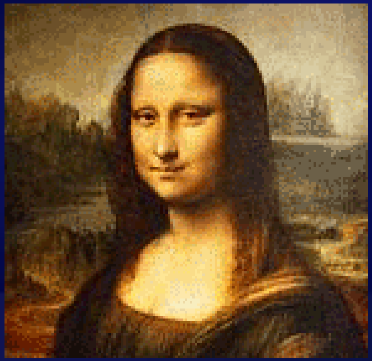


Table 1 Clinical significance of PALS values in HFpEF patients according to different studies

Author	PALS (%)	Clinical value
Morris et al., 2017[42]	< 23	72.8% sensitivity and 75.6% specificity for detection of LV DD, significant association with symptomatic status, NYHA functional class, elevated PCWP, HF hospitalization at 2 years
Aung et al., 2016[46]	< 17.5	89% sensitivity and 55.3% specificity for the prediction of HFpEF. Significant inverse correlation with BNP levels, DT, LAVI, LVMI
Kurt et al., 2009[49]	18 ± 4	Mean value in HFpEF patients significantly reduced (p < 0,05) vs patients with DD but no diagnosis of HF
Santos et al., 2016[63]	< 26	Increasing significant association with AF, greater LA size and LV sizes, LV mass, prevalence of hypertrophy, lower EF and LV-GLS, lower RVFAC. Increase HF hospitalization and cardiovascular death at a median follow-up of 31 months
Freed et al., 2016[65]	< 31.2	Reduced survival free of cardiovascular events or death, decreased exercise tolerance and peak VO2, PVR

Abbreviations: *HFpEF* heart failure with preserved ejection fraction; *DD* diastolic dysfunction; *AF* atrial fibrillation; *LA* left atrium, *LV* left ventricle; *EF* ejection fraction; *LV-GLS* left ventricular global longitudinal strain; *RVFAC* right ventricular fractional area change; *BNP* brain natriuretic peptide; *DT* deceleration time; *LAVI* left atrial volume index; *LVMI* left ventricular mass index; *PCWP* pulmonary capillary wedge pressure; *PVR* pulmonary vascular resistance

Mandoli et al. Heart Fail Rev (2020) 25:409-417

JACC: CARDIOVASCULAR IMAGING VOL. 13, NO. 5, 2020

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ORIGINAL RESEARCH

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ORIGINAL ARTICLE

Echocardiography WILEY

Reviews in Cardiovascular Medicine

Rev. Cardiovasc. Med. **2022**; 23(5): 154
https://doi.org/10.31083/j.rcm2305154

Review

Left Atrial Strain: Clinical Use and Future Applications—A Focused Review Article

Gergana Marincheva[1,*], Zaza Iakobishvili[1], Andrei Valdman[1], Avishag Laish-Farkash[1]

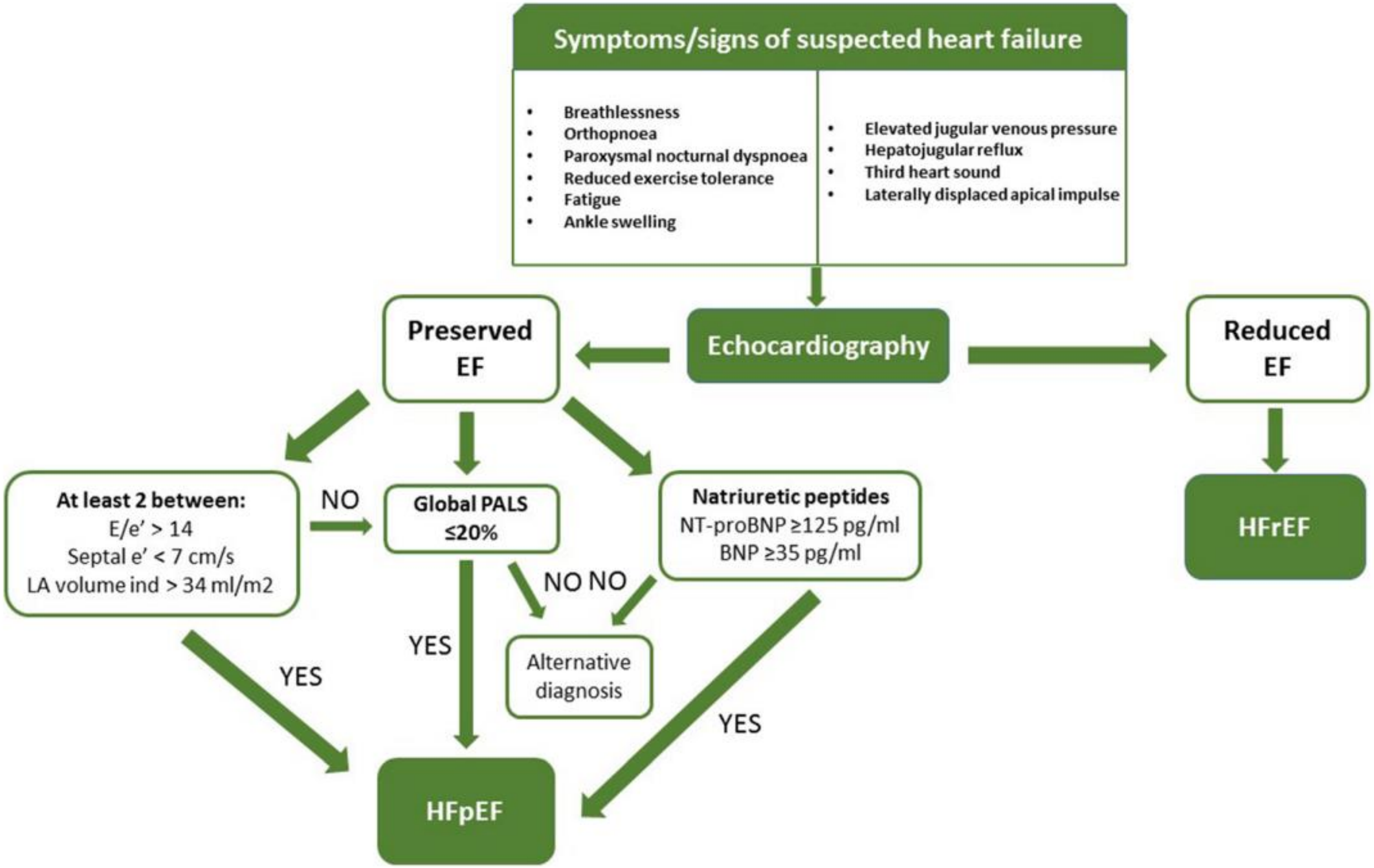

Fig. 3 Algorithm for the diagnosis of HFpEF in patients presenting with suspected symptoms and/or signs of heart failure [44]

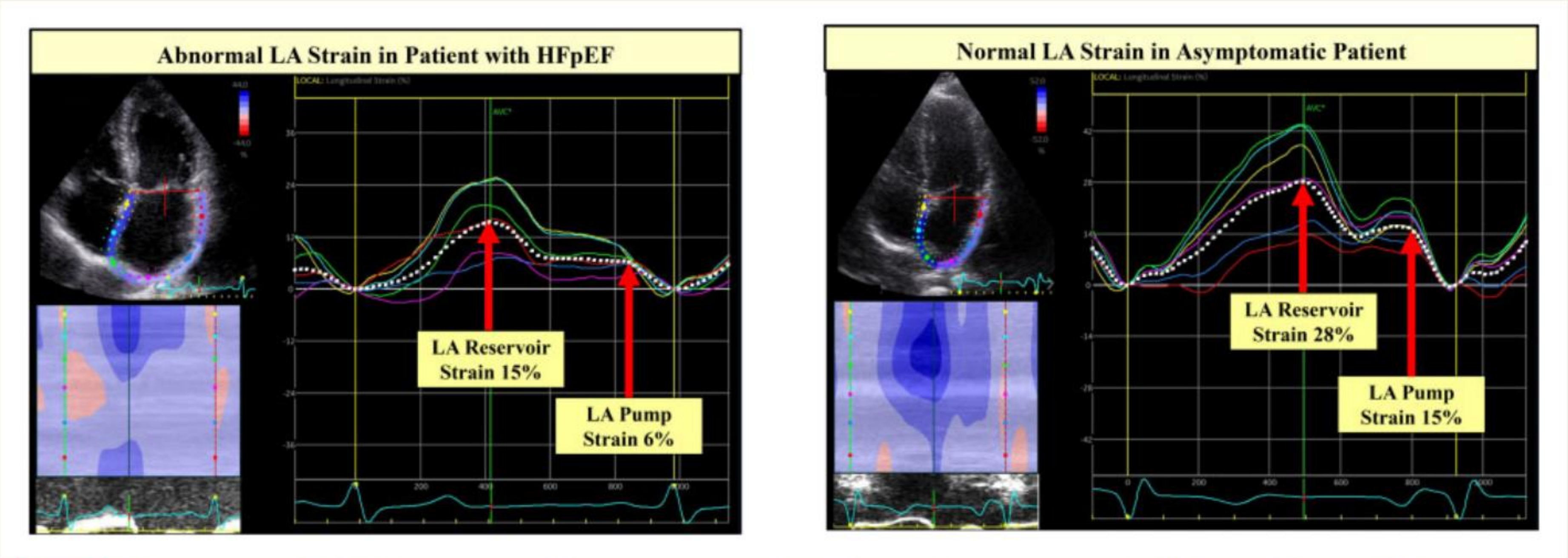

Figure 7 Measurement of left atrial strain in apical four-chamber view. The left panel shows a patient with HFpEF and abnormal LA reservoir and pump strains and in the right panel a patient with normal LA strains.

Left Atrial Strain Associated with Functional Recovery in Patients Receiving Optimal Treatment for Heart Failure

Check for updates

Yuta Torii, PhD, Kenya Kusunose, MD, PhD, FASE, Yukina Hirata, PhD, Susumu Nishio, PhD, Takayuki Ise, MD

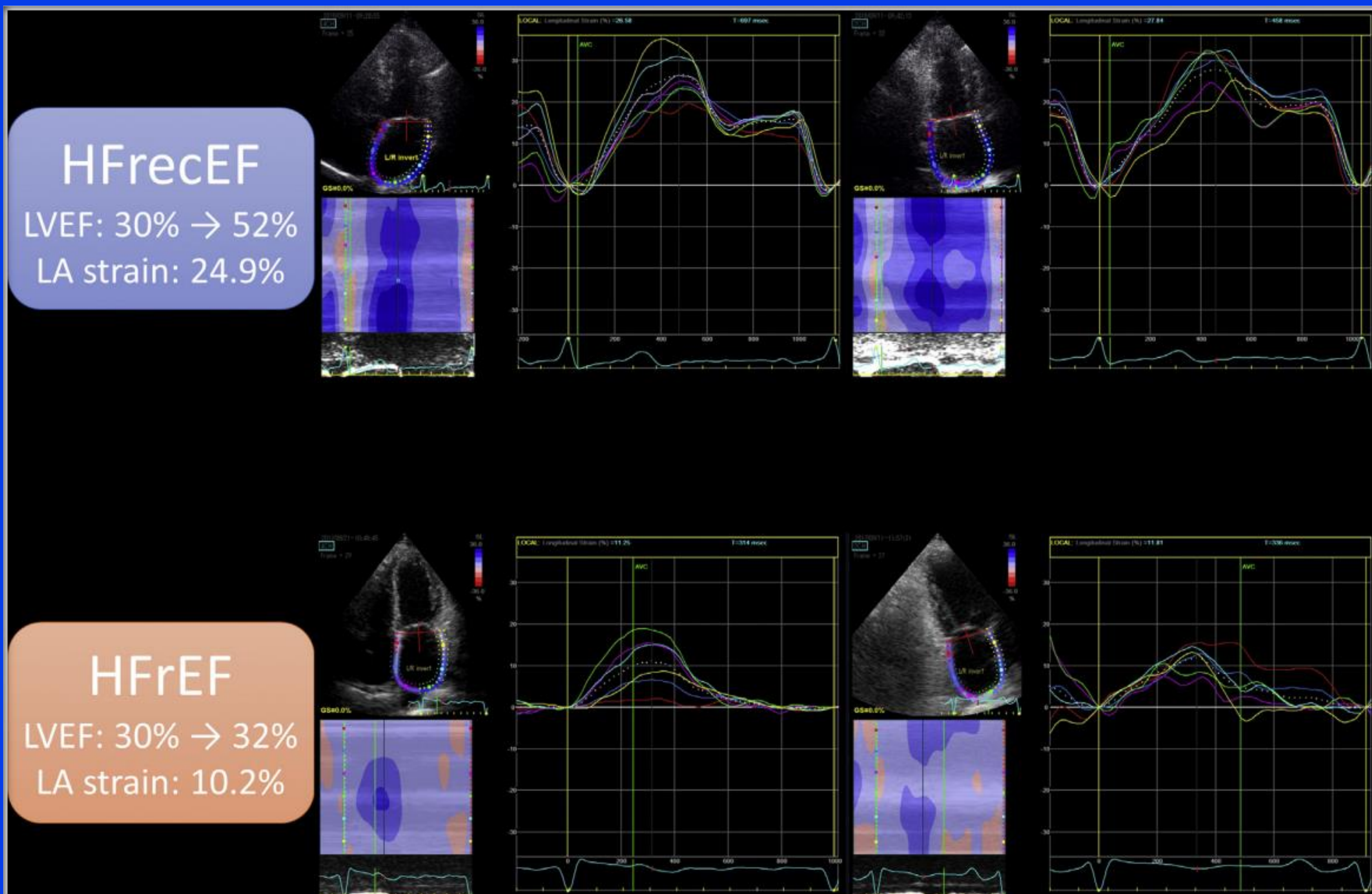

Figure 2 Representative cases of preserved LA strain with HFrecEF *(top)* and reduced LA strain with HFrEF *(bottom)*.

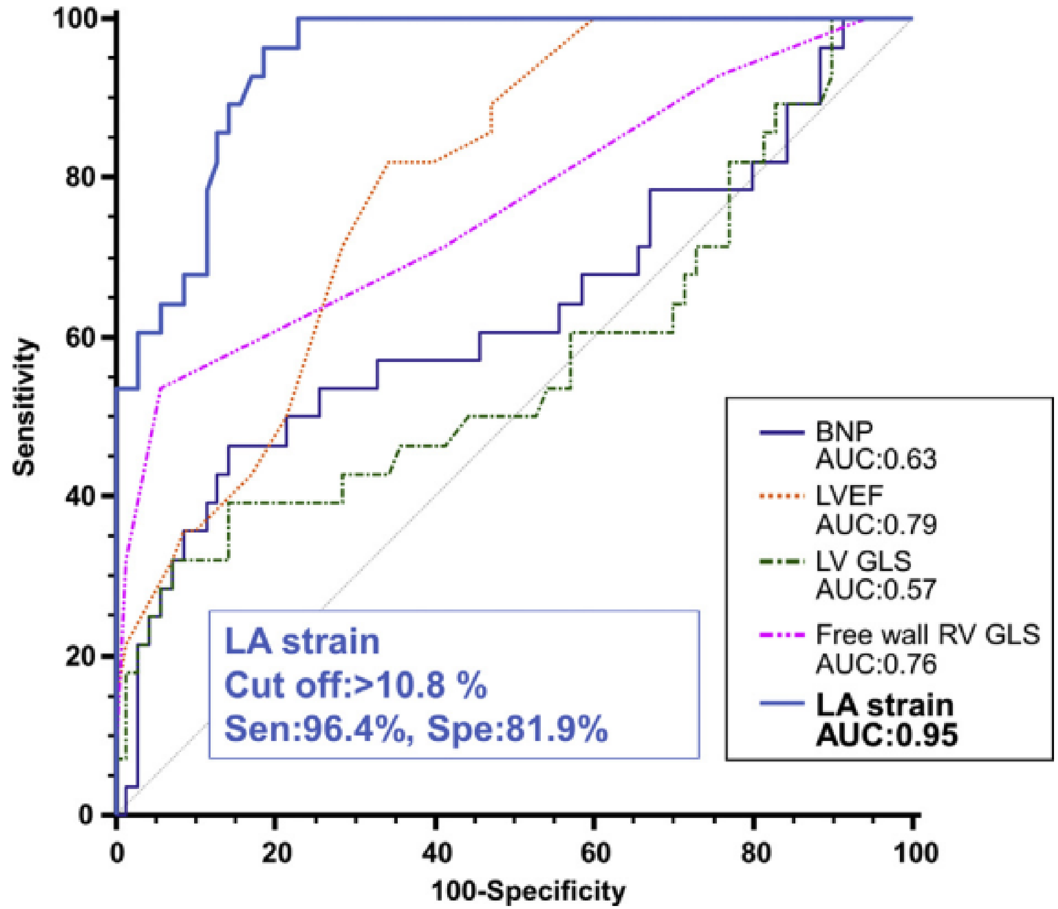

Figure 3 Receiver operating characteristic analysis of associations in patients with HFrecEF. LA strain had the highest area under the curve (AUC; 0.95) among clinical and echocardiographic variables. *BNP*, Brain natriuretic peptide; *Sen*, sensitivity; *Spe*, specificity.

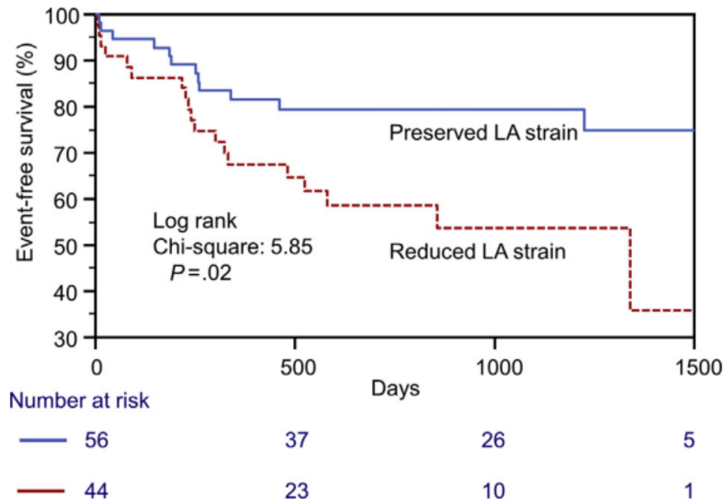

Figure 5 Kaplan-Meier analysis of event-free survival by LA strain. Patients were stratified by groups with preserved (*blue curve*, *n* = 56) and reduced (*red curve*, *n* = 44) LA strain.

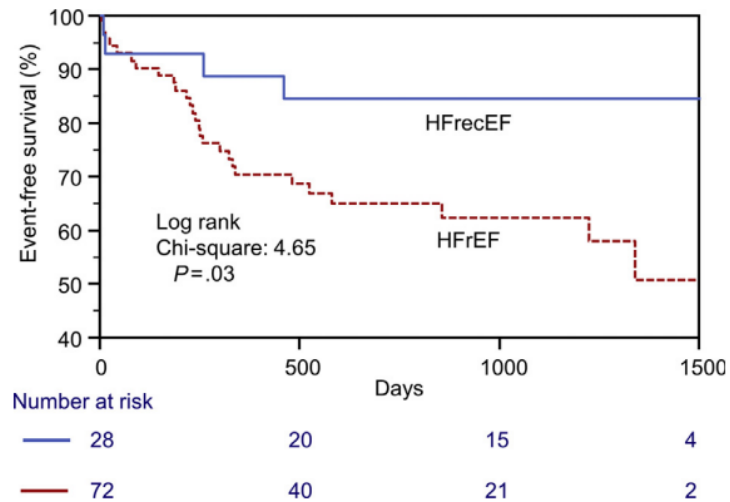

Figure 6 Kaplan-Meier analysis of event-free survival. Patients were stratified into groups with HFrecEF (*blue curve*, *n* = 28) and HFrEF (*red curve*, *n* = 72).

HIGHLIGHTS

- LA strain at admission predicts HFrecEF in patients with optimal treatments of HF.
- LA strain could be a predictor of EF changes and subsequent CV death in HFrecEF.
- LA strain should be considered in patients with low ejection fractions on admission.

Atrial Fibrillation

European Heart Journal - Cardiovascular Imaging (2022) **23**, 52–60
doi:10.1093/ehjci/jeab202

Left atrial strain predicts incident atrial fibrillation in the general population: the Copenhagen City Heart Study

Raphael Hauser[1]*, Anne Bjerg Nielsen [1], Kristoffer Grundtvig Skaarup[1], Mats Christian Højbjerg Lassen[1], Lisa Steen Duus[1], Niklas Dyrby Johansen [1], Morten Sengeløv[1], Jacob Louis Marott [2], Gorm Jensen[2], Peter Schnohr[2], Peter Søgaard[2,3,4], Rasmus Møgelvang[2,5,6,7], and Tor Biering-Sørensen [1,2,7]

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ESC
European Society of Cardiology

European Heart Journal - Cardiovascular Imaging (2022) **23**, 74–84
https://doi.org/10.1093/ehjci/jeab222

The prognostic impact of mechanical atrial dysfunction and atrial fibrillation in heart failure with preserved ejection fraction

Jerremy Weerts [1]*, Arantxa Barandiarán Aizpurua [1], Michiel T.H.M. Henkens [1], Aurore Lyon [2], Manouk J.W. van Mourik [1], Mathijs R.A.A. van Gemert[1], Anne Raafs [1], Sandra Sanders-van Wijk [3], Antoni Bayés-Genís [4], Stephane R.B. Heymans [1,5], Harry J.G.M. Crijns [1], Hans-Peter Brunner-La Rocca [1], Joost Lumens [2], Vanessa P.M. van Empel [1]†, and Christian Knackstedt [1]†

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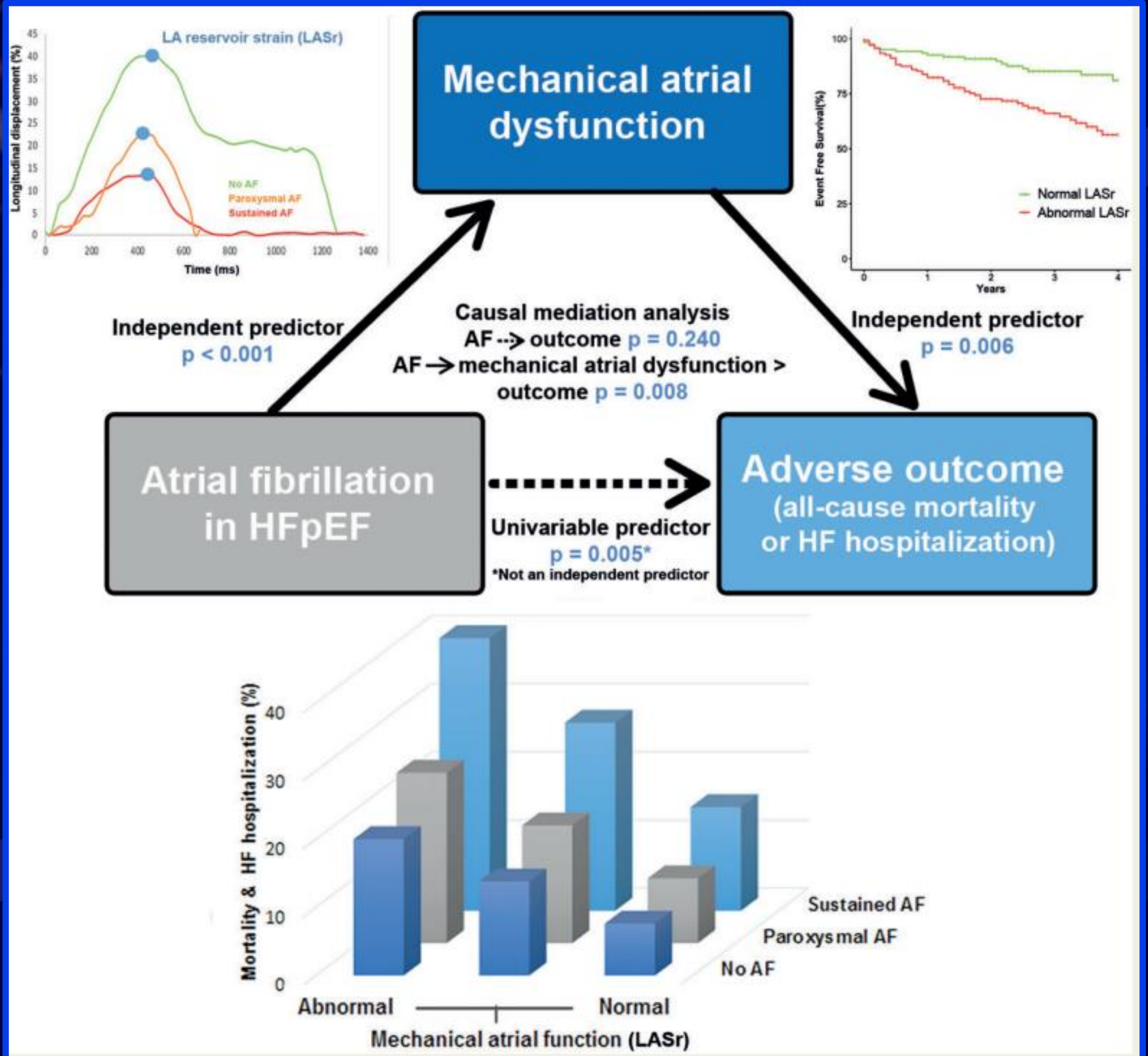

LA reservoir strain (LASr)
Longitudinal displacement (%)
Time (ms)
No AF
Paroxysmal AF
Sustained AF
Mechanical atrial dysfunction
Event Free Survival(%)
Years
Normal LASr
Abnormal LASr
Independent predictor
p < 0.001
Causal mediation analysis
AF --> outcome p = 0.240
AF → mechanical atrial dysfunction > outcome p = 0.008
Independent predictor
p = 0.006
Atrial fibrillation in HFpEF
Univariable predictor
p = 0.005*
*Not an independent predictor
Adverse outcome
(all-cause mortality or HF hospitalization)
Mortality & HF hospitalization (%)
Sustained AF
Paroxysmal AF
No AF
Abnormal
Normal
Mechanical atrial function (LASr)

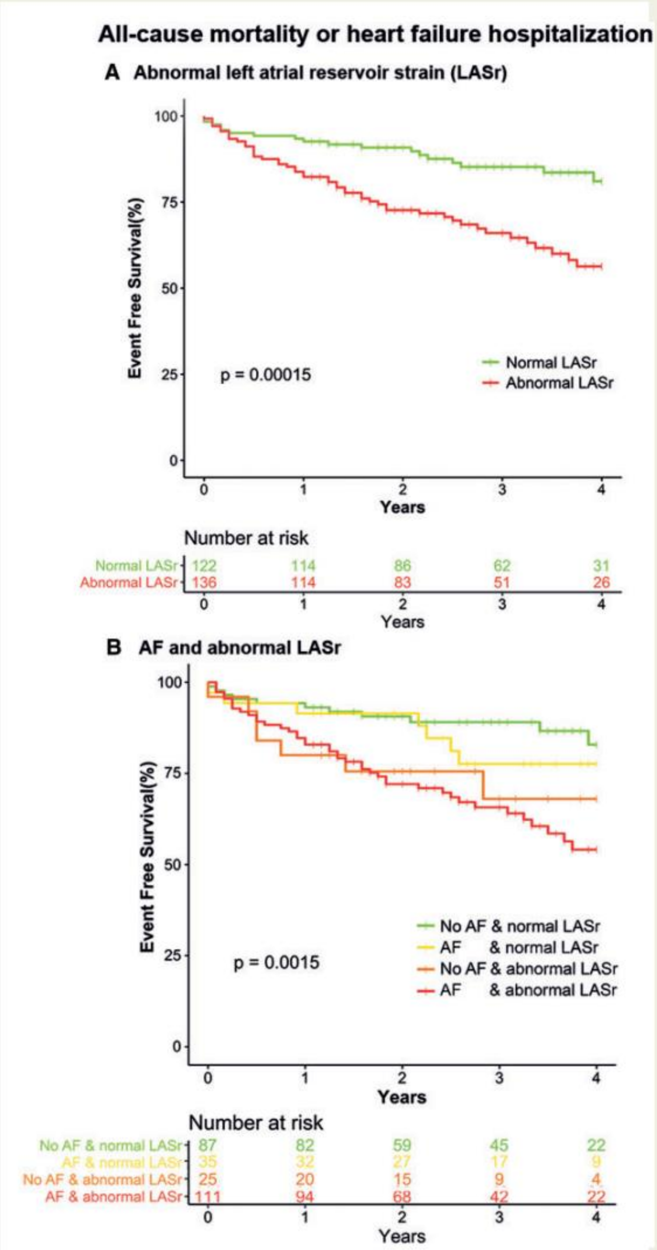

Figure 3 Kaplan–Meier survival curves for freedom of heart failure hospitalization or all-cause mortality for (*A*) abnormal left atrial reservoir strain (LASr) (defined as <22.7%) and (*B*) atrial fibrillation (AF) presence and abnormal LASr combined.

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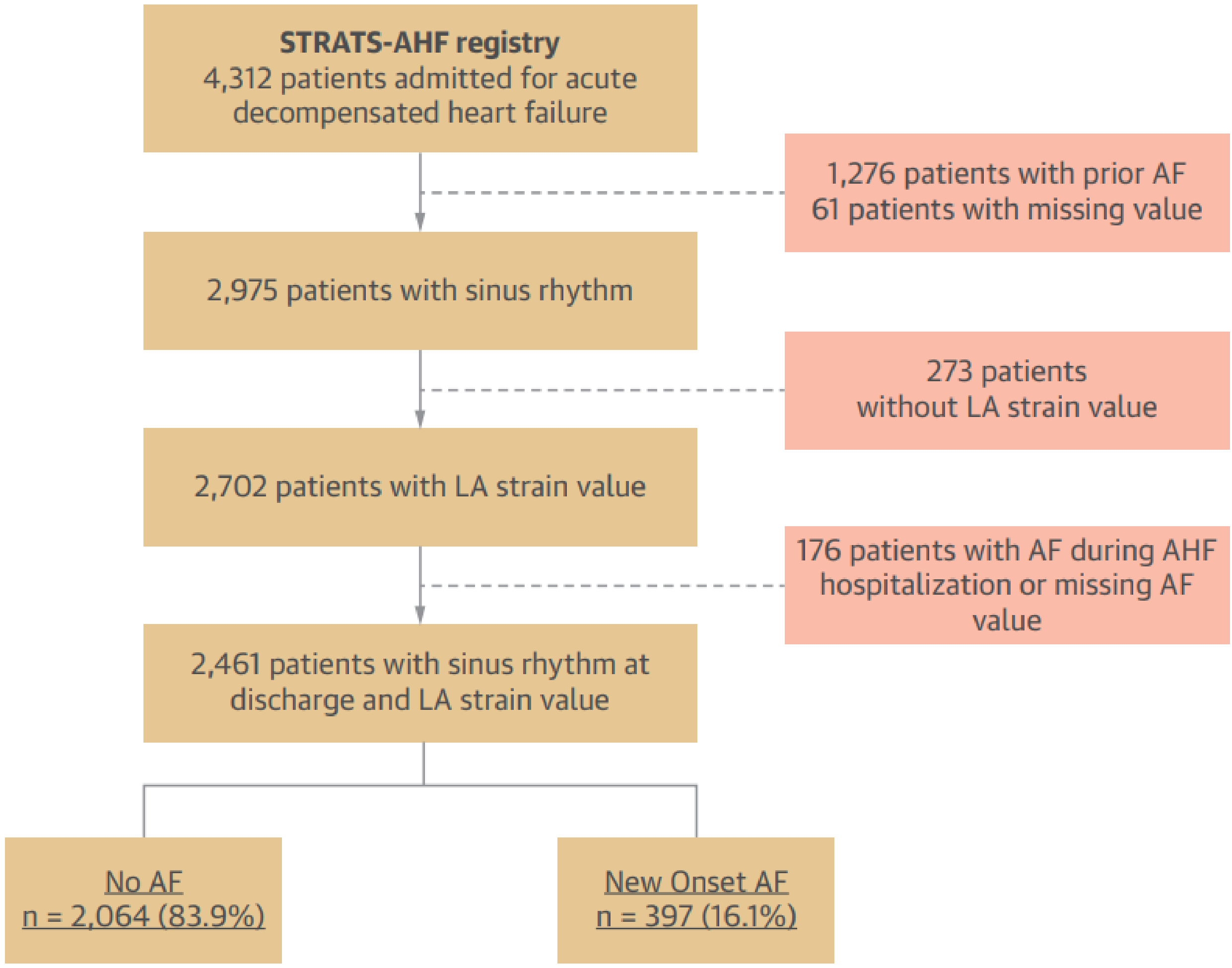
ORIGINAL RESEARCH

Left Atrial Strain as a Predictor of New-Onset Atrial Fibrillation in Patients With Heart Failure

Jin Joo Park, MD, PhD,[a,*] Jae-Hyeong Park, MD, PhD,[b,*] In-Chang Hwang, MD,[a] Jun-Bean Park, MD, PhD,[c] Goo-Yeong Cho, MD, PhD,[a] Thomas H. Marwick, MBBS, PhD, MPH[d]

FIGURE 1 **Study Population**



Of the 4,312 patients who were included in the STRATS-AHF (Strain for Risk Assessment and Therapeutic Strategies in Patients With Acute Heart Failure) registry, 2,461 patients with sinus rhythm and LA strain value were analyzed. During the 5-year follow-up, 397 (16.1%) patients developed new onset AF. AF = atrial fibrillation; LA = left atrium.

FIGURE 2 New-Onset Atrial Fibrillation During 5-Year Follow-Up

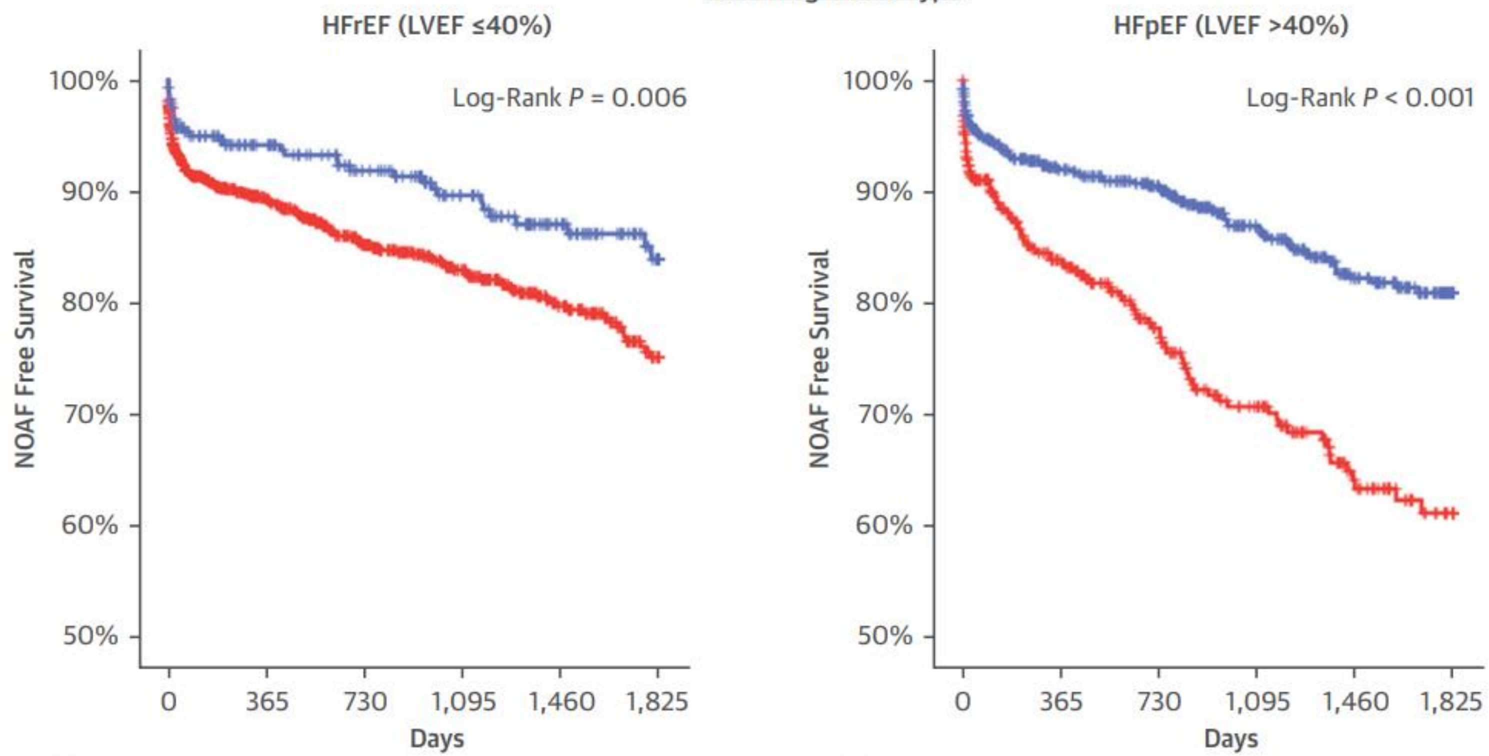
A

New Onset AF - All Patients

FIGURE 2 Continued

B

According the HF type



HFrEF (LVEF ≤40%)

No at risk	0	365	730	1,095	1,460	1,825
PALS >18%	285	218	189	147	109	68
PALS ≤18%	1,098	718	536	430	262	144

HFpEF (LVEF >40%)

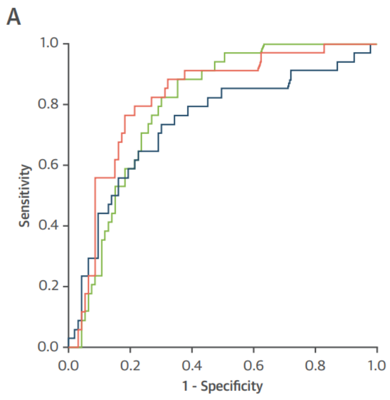
No at risk	0	365	730	1,095	1,460	1,825
PALS >18%	620	458	397	295	206	135
PALS ≤18%	409	253	179	132	80	43

— PALS >18% — PALS ≤18%

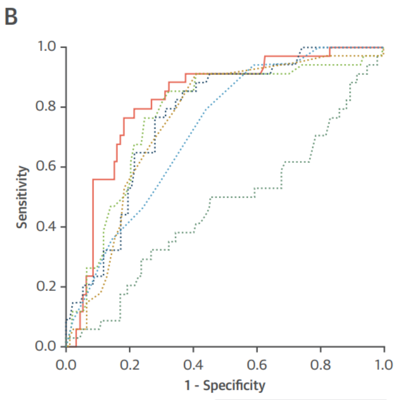
— PALS >18% — PALS ≤18%

fraction; HFrEF = heart failure with reduced ejection fraction; LAVI = left atrium volume index; NOAF = new-onset atrial fibrillation; PALS = peak atrial longitudinal strain.

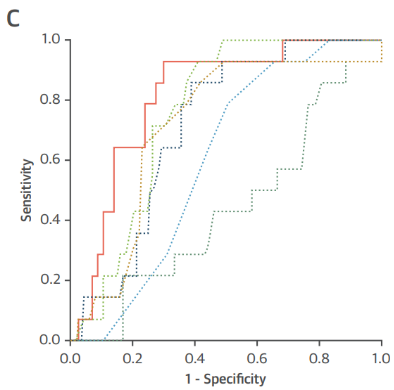
FIGURE 4 ROC Curves for Prediction of Clinical Events



	AUC	95% CI
LA Reservoir Strain	0.82	0.74 to 0.90
LA Conduit Strain	0.80	0.72 to 0.87
LA Contraction Strain	0.74	0.64 to 0.84



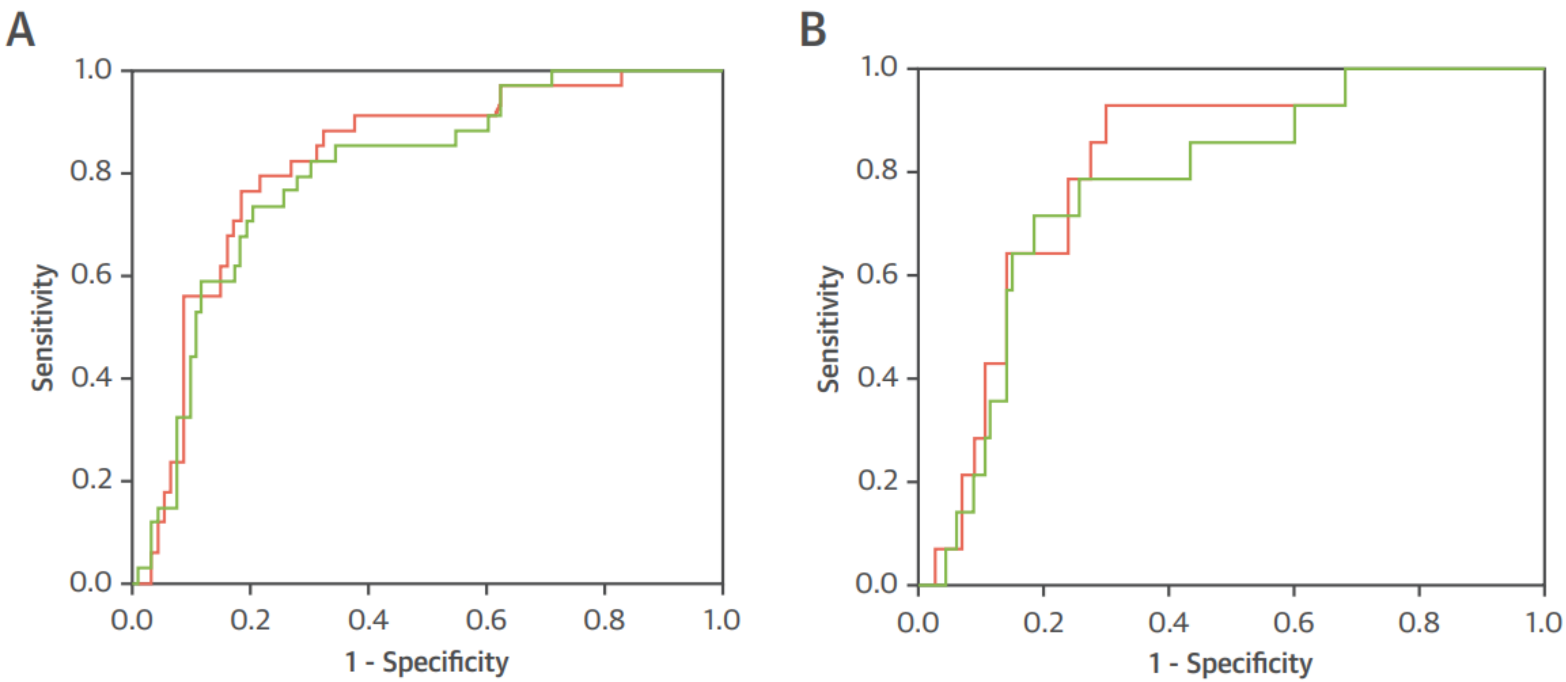
	AUC	95% CI
LA Reservoir Strain	0.82	0.74 to 0.90
LAV Max	0.77	0.68 to 0.87
E/E' Ratio	0.77	0.69 to 0.86
E'	0.72	0.63 to 0.81
LVEF	0.47	0.35 to 0.58
LV GLS	0.76	0.66 to 0.85



	AUC	95% CI
LA Reservoir Strain	0.81	0.71 to 0.91
LAV Max	0.76	0.67 to 0.85
E/E' Ratio	0.71	0.61 to 0.82
E'	0.60	0.49 to 0.71
LVEF	0.43	0.28 to 0.59
LV GLS	0.71	0.58 to 0.84

(A) Strains of all phases for prediction cardiovascular events. **(B)** LA systolic strain and various echocardiographic measurements for prediction of cardiovascular events. **(C)** LA systolic strain and various echocardiographic measurements for prediction of new onset of atrial fibrillation. AUC = area under the curve; other abbreviations as in Figure 1.

FIGURE 5 ROC Curves for Prediction of Clinical Events—Measured vs Predicted LA Strain



A

	AUC	95% CI
LA Reservoir Strain (Measured)	0.82	0.74 to 0.90
LA Reservoir Strain (Predicted)	0.80	0.72 to 0.88

B

	AUC	95% CI
LA Reservoir Strain (Measured)	0.81	0.71 to 0.91
LA Reservoir Strain (Predicted)	0.78	0.66 to 0.89

(A) Measured **(red)** and predicted **(blue)** LA systolic strain for prediction of cardiovascular events; **(B)** measured and predicted LA systolic strain for prediction of new onset of atrial fibrillation. Abbreviations as in Figures 1 and 4.

Arrhythmias and sudden death

openheart

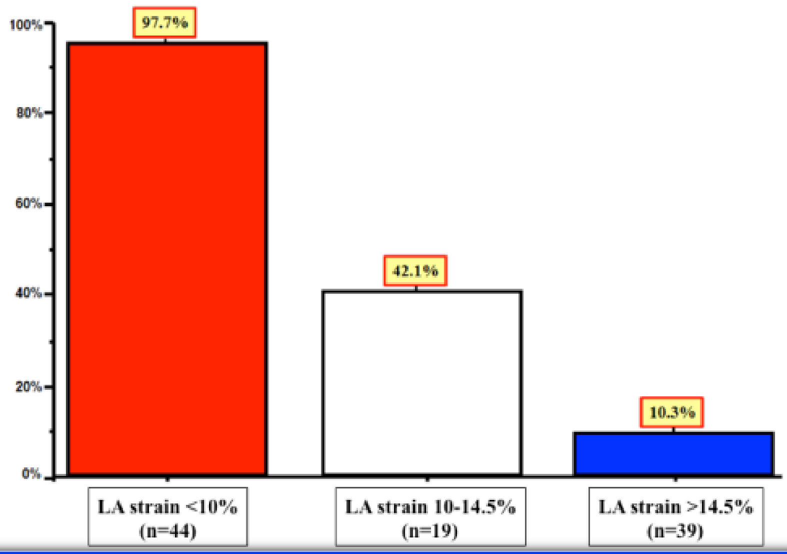
Left atrial strain predicts recurrence of atrial arrhythmias after catheter ablation of persistent atrial fibrillation

Abdul Shokor Parwani, Daniel-Armando Morris, Florian Blaschke, Martin Huemer, Burkert Pieske, Wilhelm Haverkamp, Leif-Hendrik Boldt

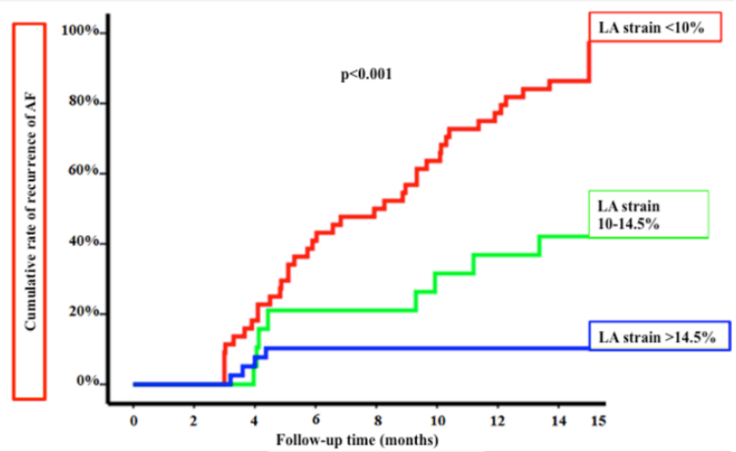
Table 3 Clinical and echocardiographic predictors of recurrence of AF after one catheter ablation (CA) procedure (primary endpoint)

	Recurrence of AF after one CA procedure					
	Univariate Cox analysis			Multivariate Cox analysis		
Predictors	HR	95% CI	p Value	HR	95% CI	p Value
LA myocardial characteristics						
LA strain <10%	9.5	4.9 to 18.5	<0.001	6.4	2.4 to 16.9	<0.001
LA strain 10–14.5%	0.7	0.3 to 1.4	0.305	0.7	0.3 to 1.4	0.305
LA strain >14.5%	0.07	0.02 to 0.2	<0.001	0.2	0.05 to 0.7	<0.001
LA enlargement						
LA diameter >40 mm	1.3	0.7 to 2.2	0.281	0.9	0.4 to 1.9	0.978
LA area >20 cm²	1.5	0.9 to 2.6	0.107	1.5	0.9 to 2.6	0.107
LA volume >58 mL	1.3	0.7 to 2.2	0.330	1.3	0.7 to 2.2	0.330
LAVI >28 mL/m²	1.8	1.0 to 3.0	0.033	1.6	0.5 to 5.2	0.376
LV function and remodelling						
LV hypertrophy	0.9	0.5 to 1.6	0.923	0.8	0.4 to 1.5	0.579
LV longitudinal systolic dysfunction	2.4	1.0 to 5.7	0.036	0.4	0.1 to 1.5	0.214
LV longitudinal diastolic dysfunction	1.5	0.8 to 2.9	0.161	0.5	0.2 to 1.2	0.146
Clinical characteristics						
>75 years of age	1.7	0.8 to 3.4	0.122	0.4	0.1 to 1.4	0.187
Type II diabetes	0.9	0.3 to 2.3	0.861	0.4	0.1 to 2.0	0.289
Hypertension	1.7	0.9 to 3.4	0.091	1.8	0.8 to 4.1	0.121
Obesity	0.8	0.4 to 1.4	0.499	0.5	0.2 to 1.0	0.087
History of CAD	1.7	0.9 to 3.0	0.059	2.0	0.9 to 4.5	0.076
CHA_2DS_2-VASc score ≥2	2.2	1.2 to 4.1	0.011	0.8	0.3 to 2.1	0.802
$CHADS_2$ score ≥2	1.0	0.5 to 2.0	0.989	1.5	0.4 to 5.6	0.471
PVI alone	0.9	0.5 to 1.6	0.887	0.9	0.5 to 1.6	0.887
PVI + additional LA lesions	1.0	0.6 to 1.7	0.887	0.6	0.3 to 1.3	0.250

(A) Rate of recurrence of AF after catheter ablation in relation to the values of LA strain



(B) Rate of recurrence of AF after catheter ablation during follow-up period regarding the values of LA strain



Total number of patients/patients without AF

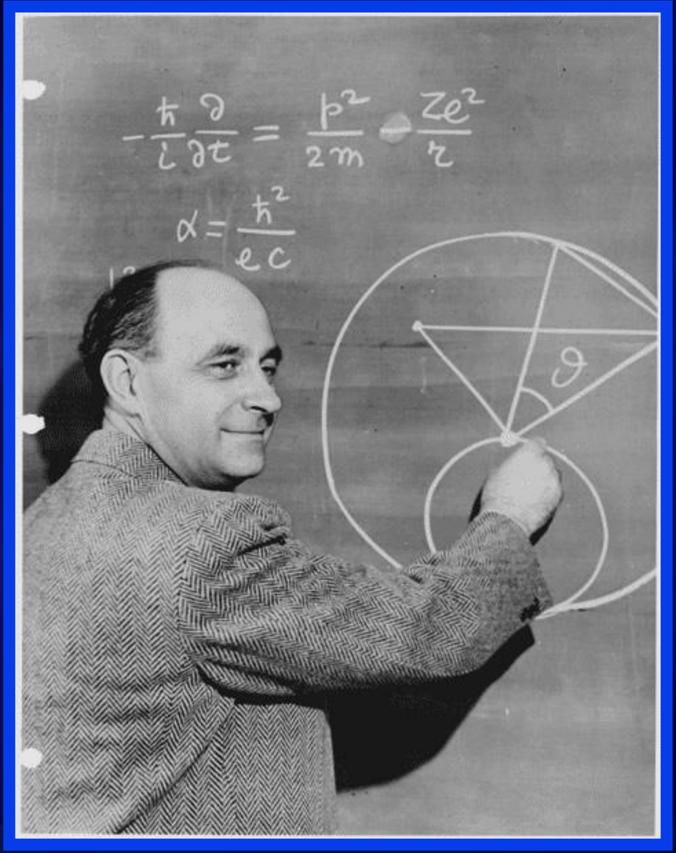
LA strain <10%:	44/44	44/44	44/43	44/25	44/21	44/15	44/9	44/5	44/1
LA strain 10-14.5%:	19/19	19/19	19/17	19/15	19/15	19/13	19/12	19/11	19/11
LA strain >14.5%:	39/39	39/39	39/36	39/35	39/35	39/35	39/35	39/35	39/35

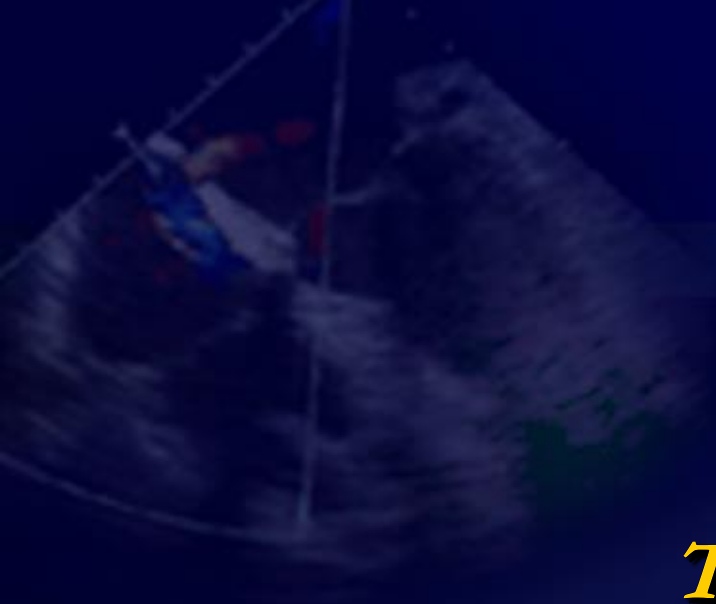
Summary

- LA strain reflects the complex interaction of LA and LV function and compliance
- LA strain measurements are challenging and variable.
- Requires training and expertise; Vendor variability
- More sensitive than LA volume change
- Clinical utility in DD/ HFpEF and AF
- Has prognostic value
- Response to therapy and Success of Rx? To be determined

"Before I came here I was confused about this subject. Having listened to your lecture I am still confused. But on a higher level"

-Enrico Fermi





Thank YOU

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