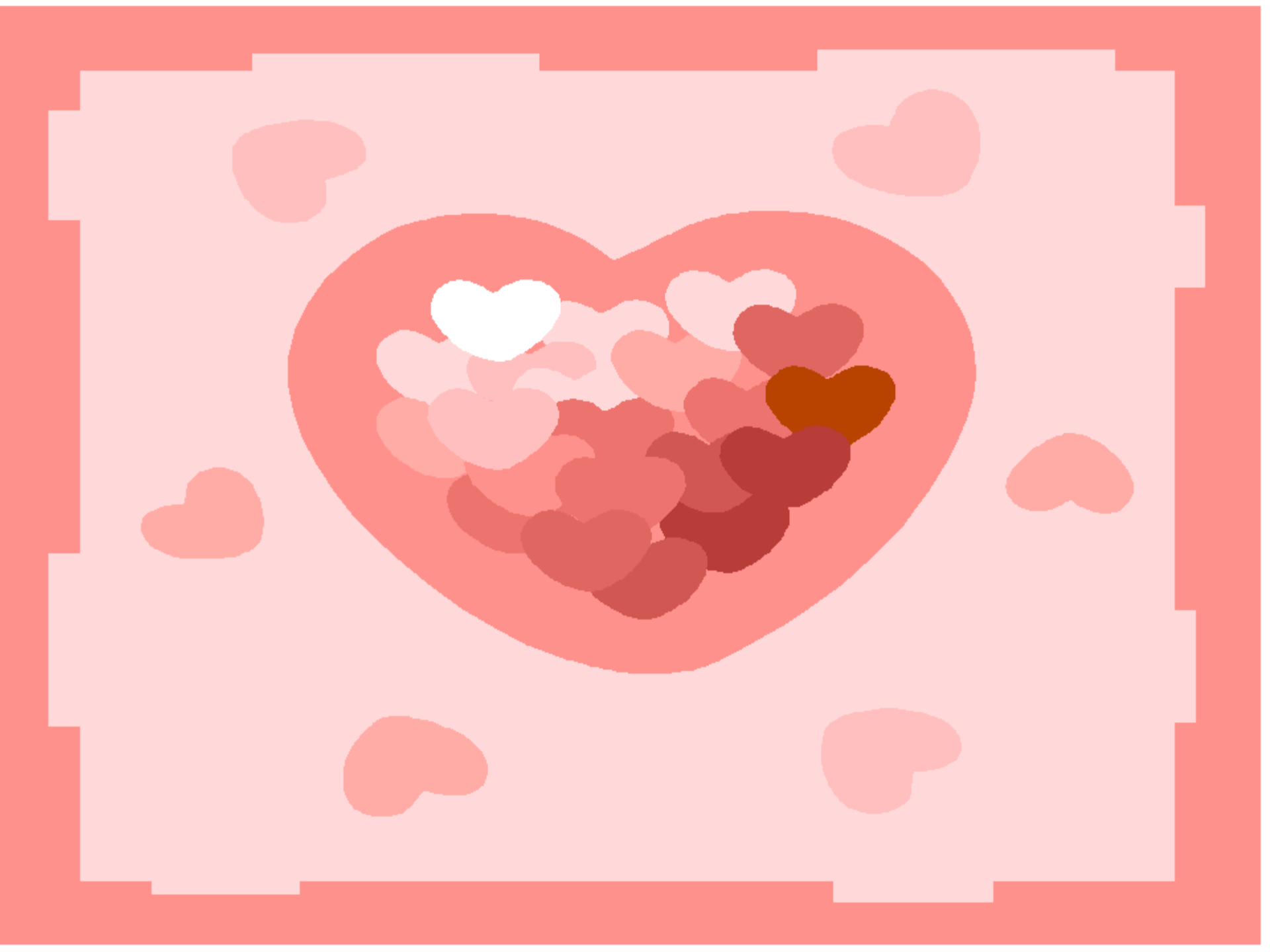
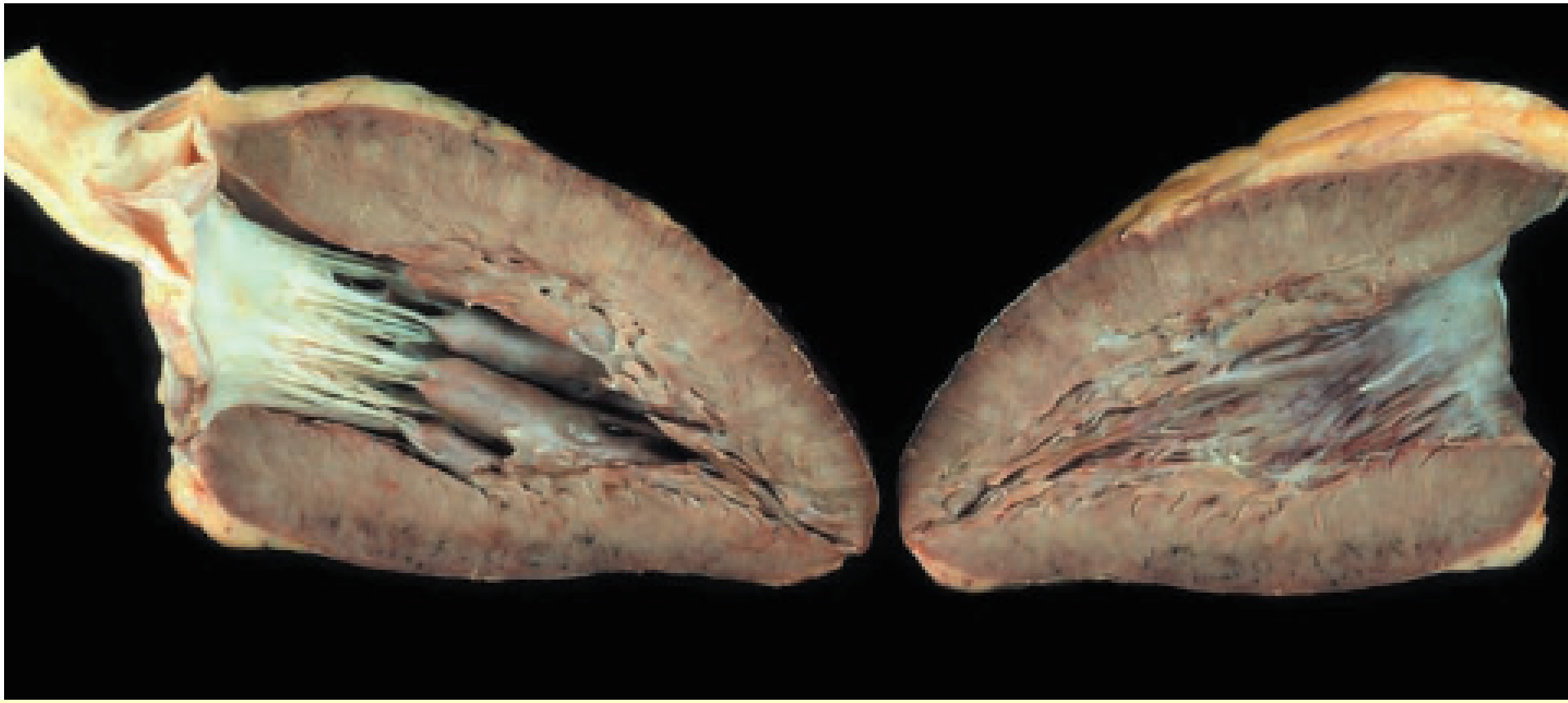
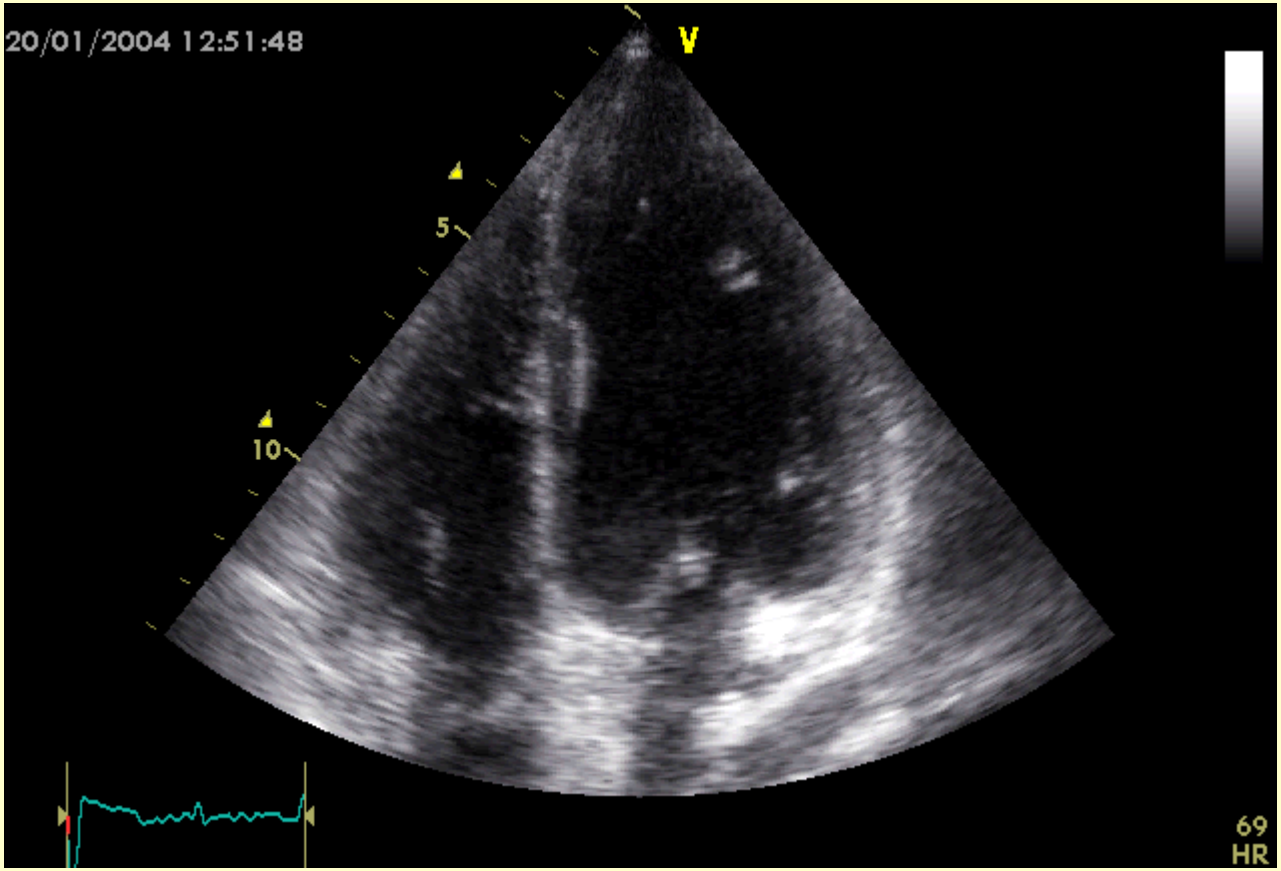
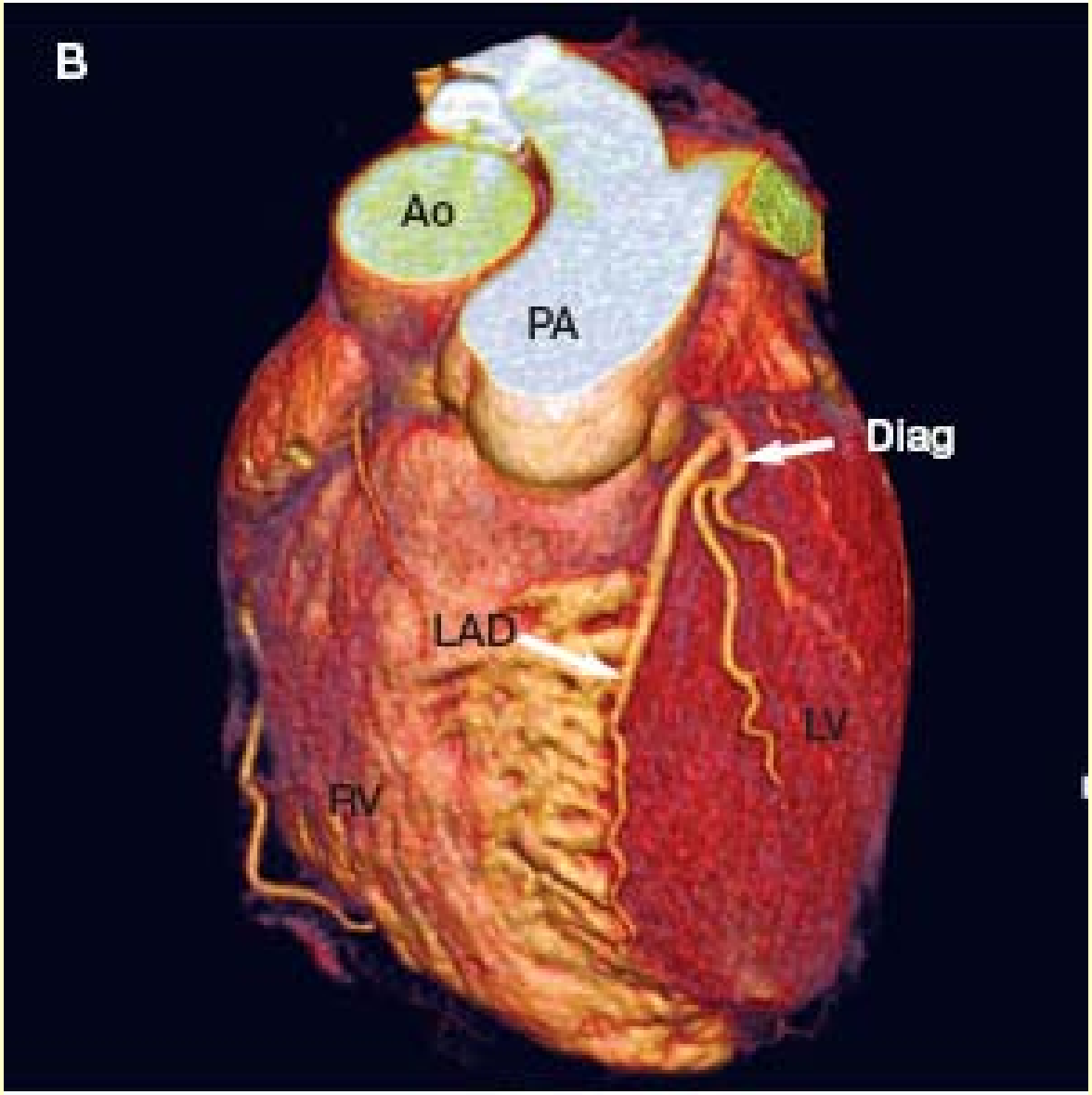
Οι προοπτικές του κλινικού ρόλου της μελέτης της συστροφής (twisting) του κοιλιακού μυοκαρδίου

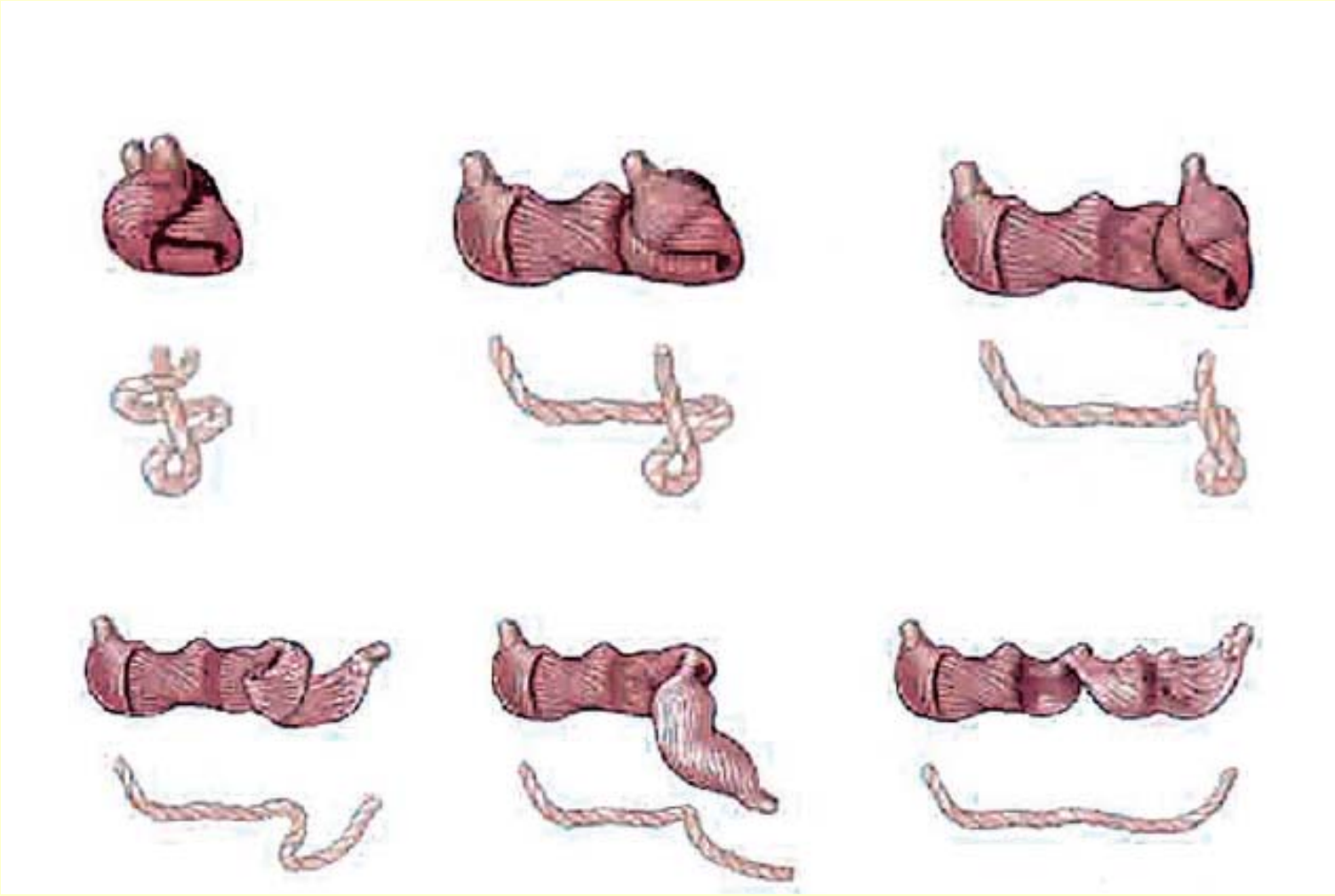
Δημήτρης Πατσούρας
Επιμελητής Β
Καρδιολογική Κλινική
ΓΝ Ιωαννίνων «Γ. Χατζηκώστα»



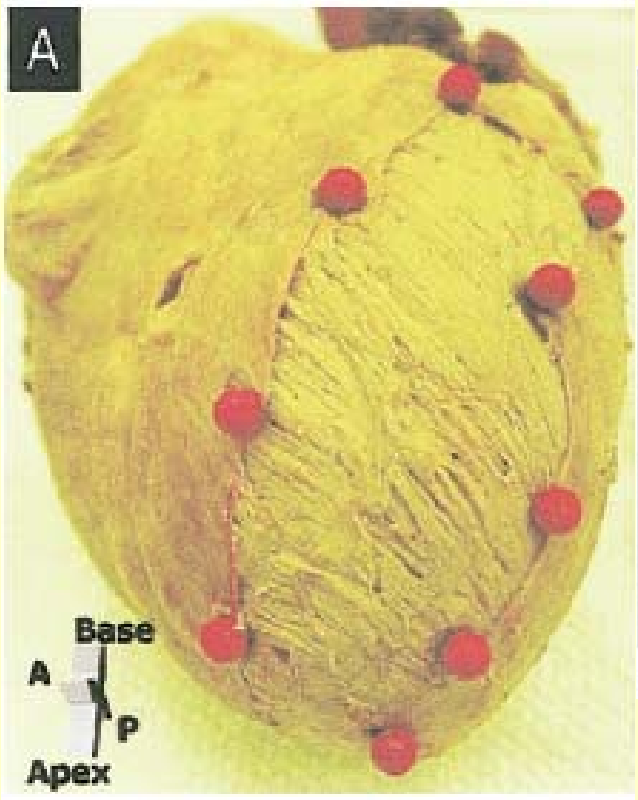


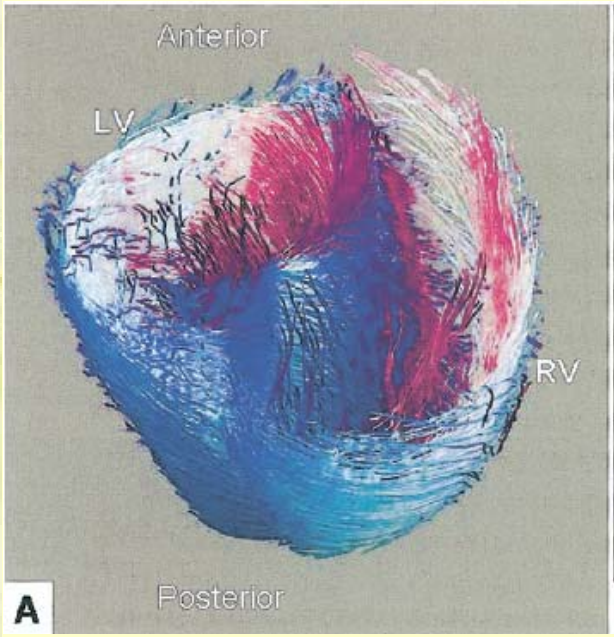

20/01/2004 12:51:48
V
5
10
69
HR

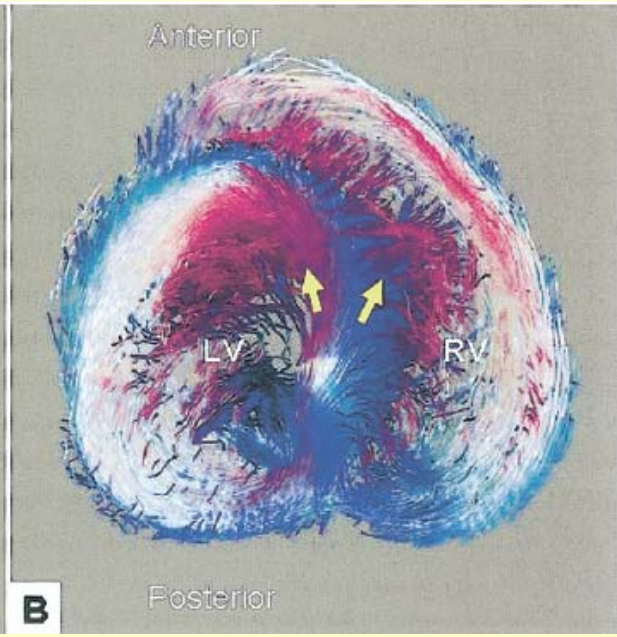

B
Ao
PA
Diag
LAD
LV
RV



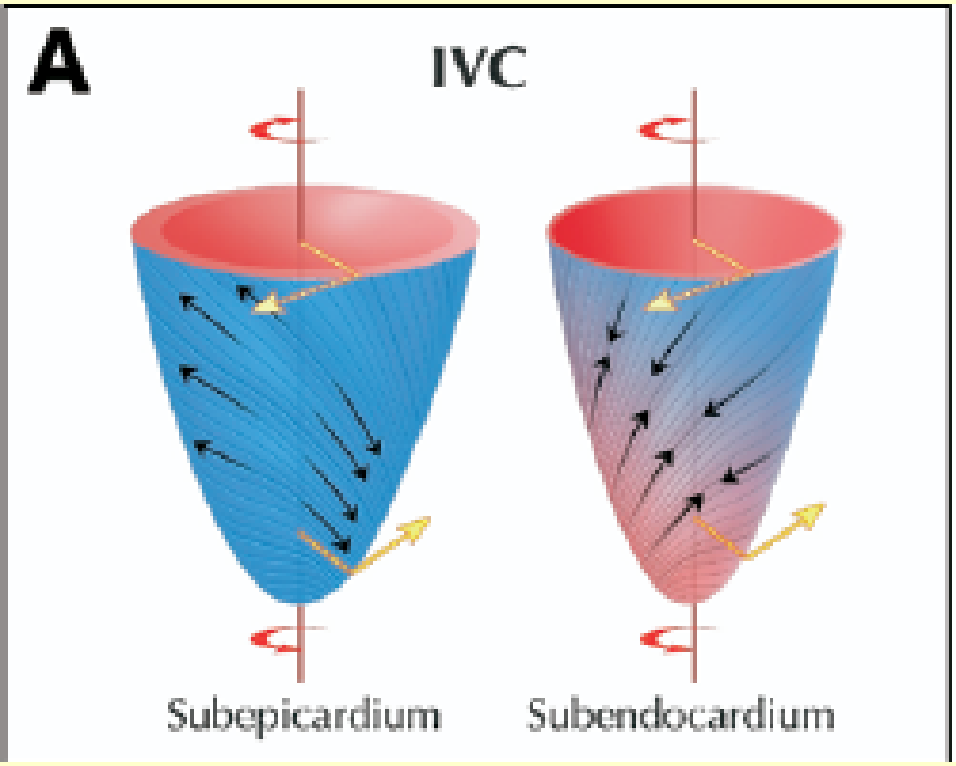

a
b

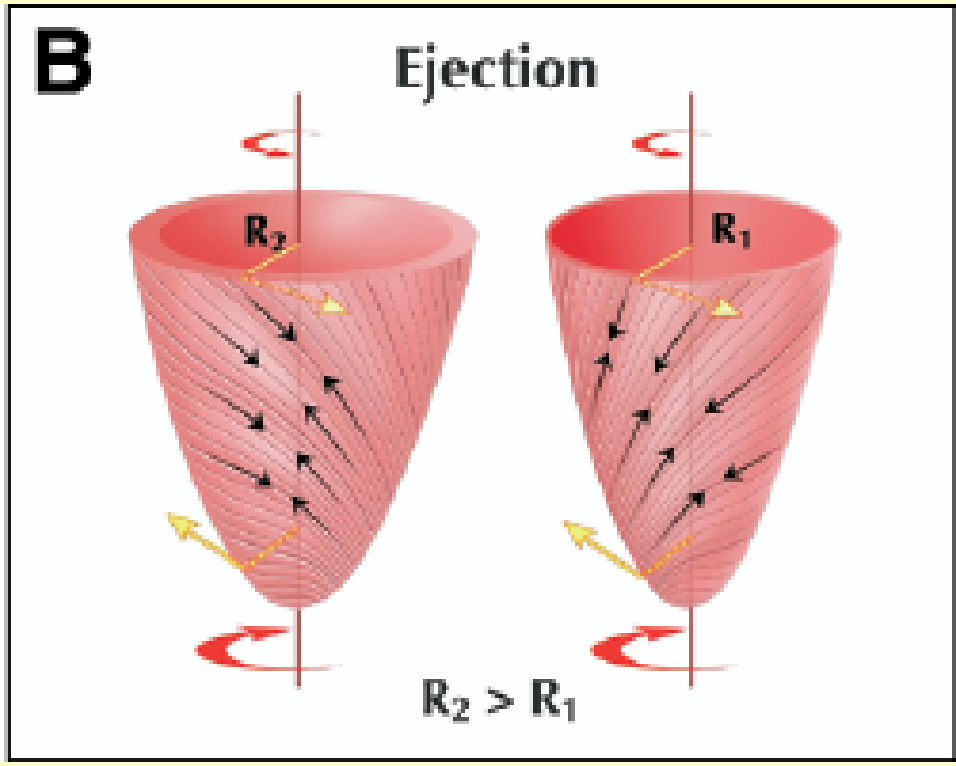

A
Base
A
P
Apex

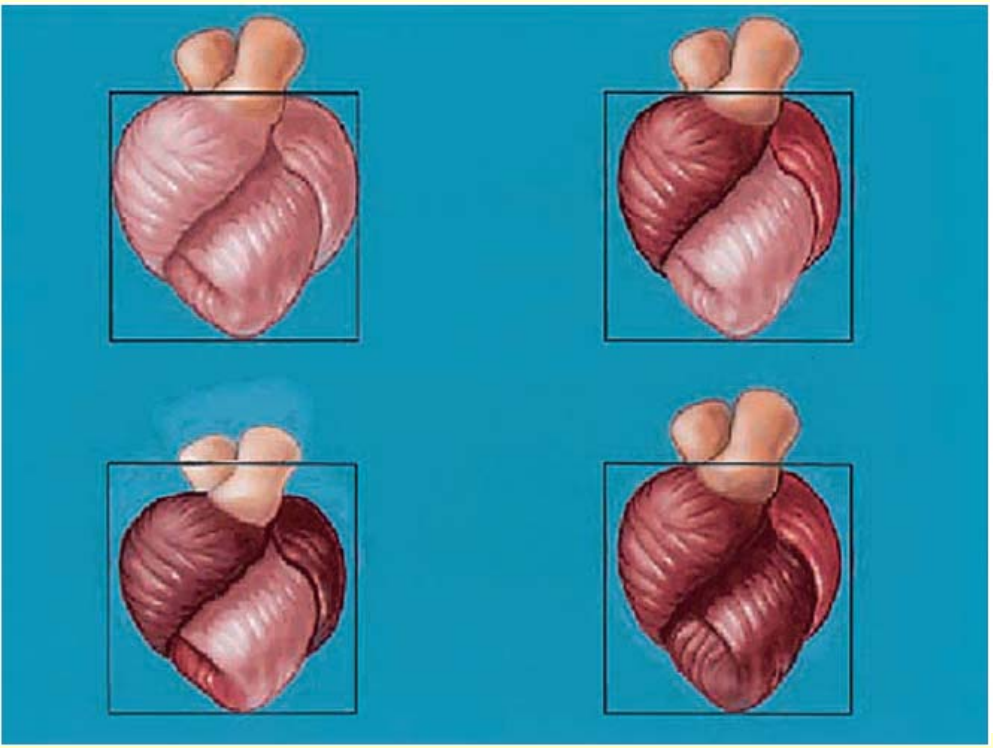

Anterior
LV
RV
A
Posterior

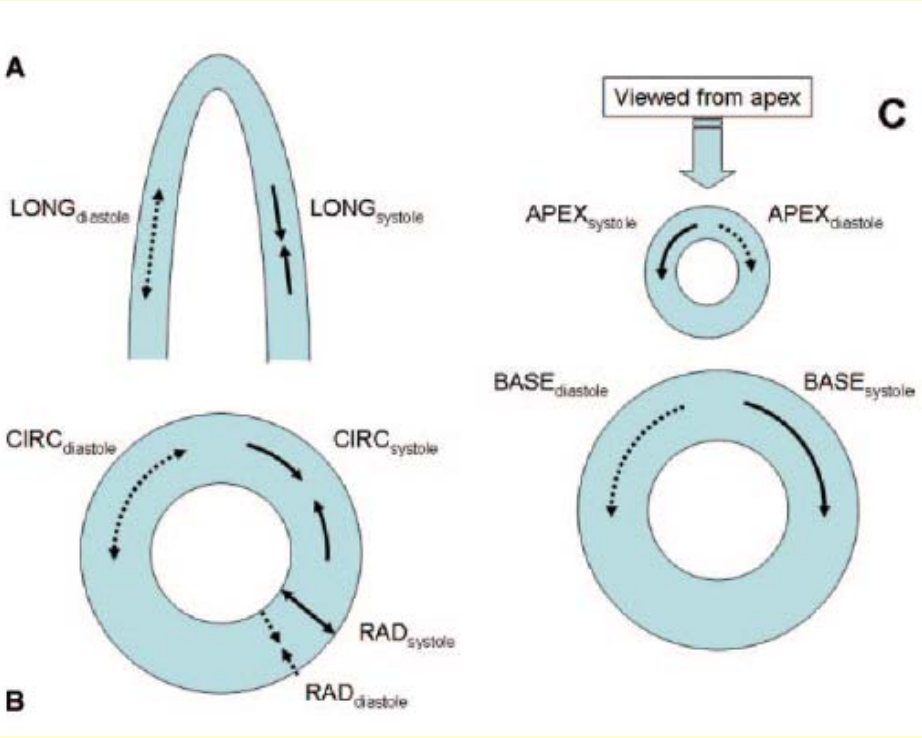

Anterior
LV
RV
B
Posterior

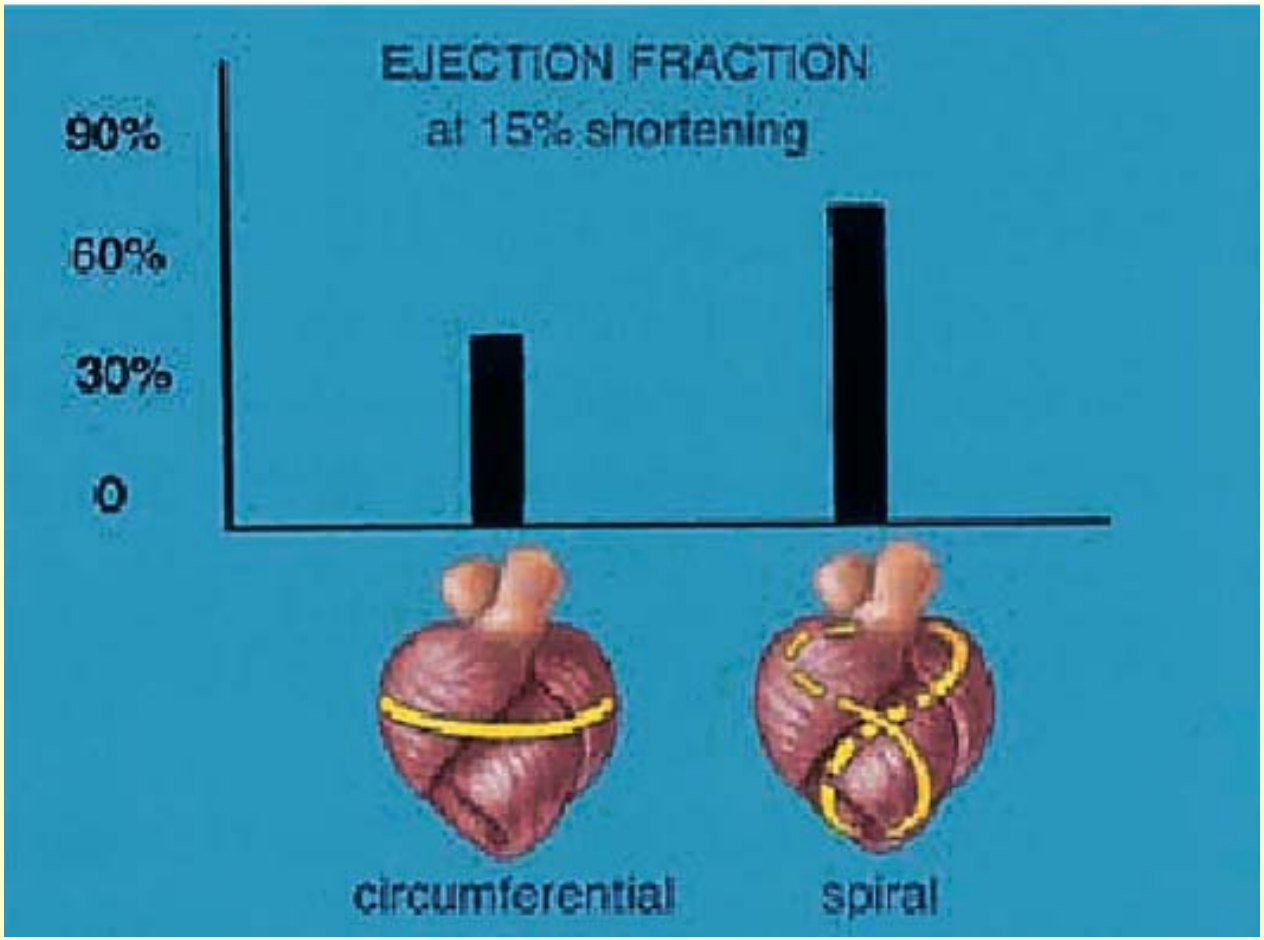

gettyimages

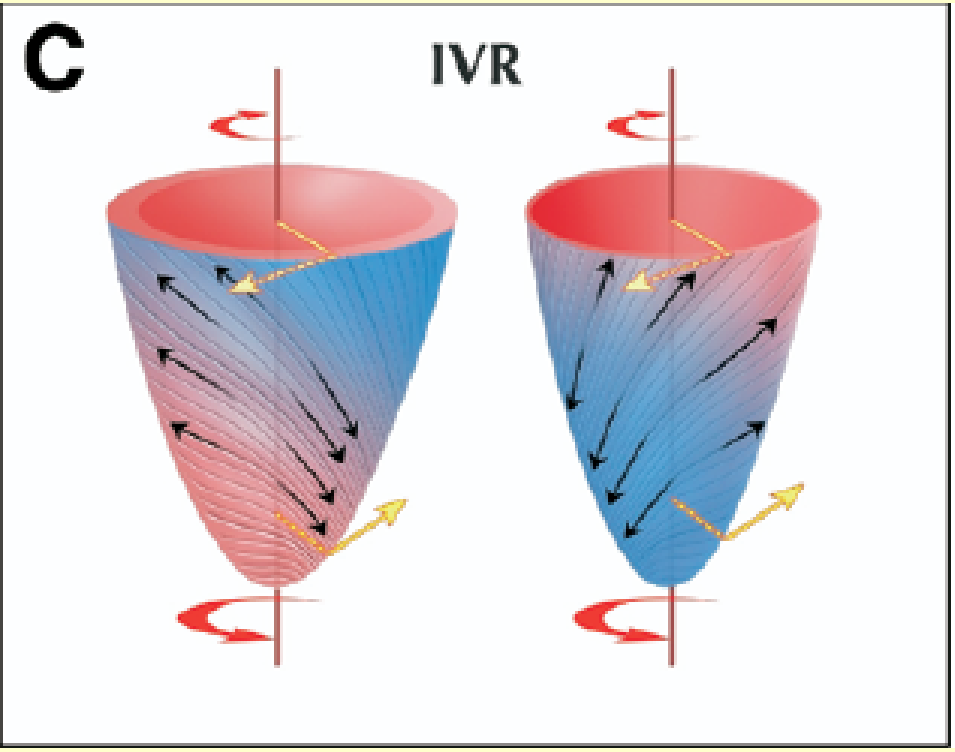

A
IVC
Subepicardium
Subendocardium

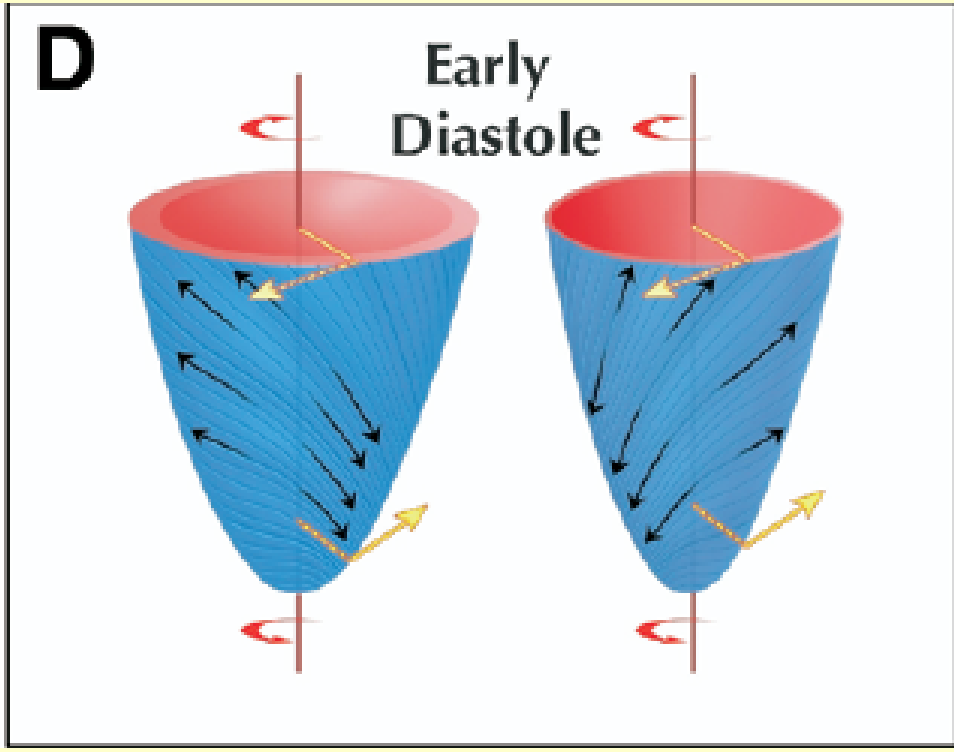

B
Ejection
R2
R1
R2 > R1




A
LONG diastole
LONG systole
CIRC diastole
CIRC systole
RAD systole
RAD diastole
B
Viewed from apex
C
APEX systole
APEX diastole
BASE diastole
BASE systole

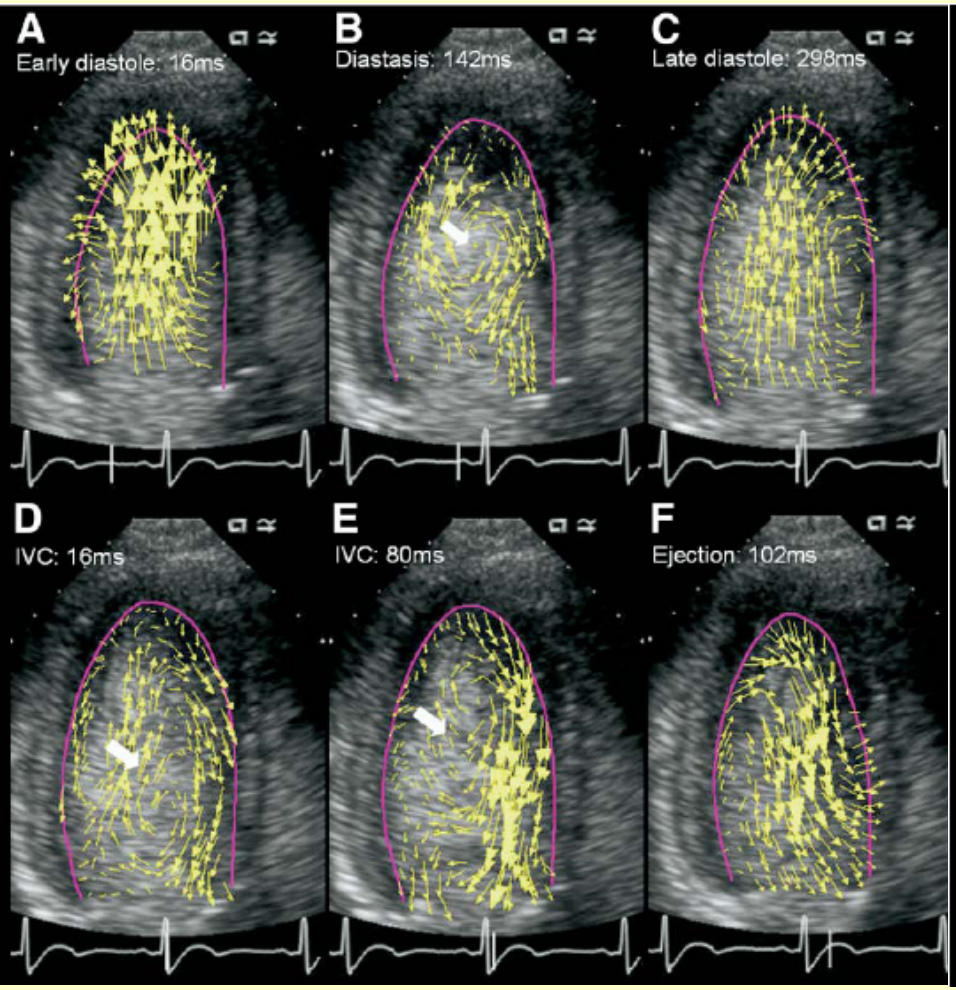

EJECTION FRACTION
at 15% shortening
90%
60%
30%
0
circumferential
spiral

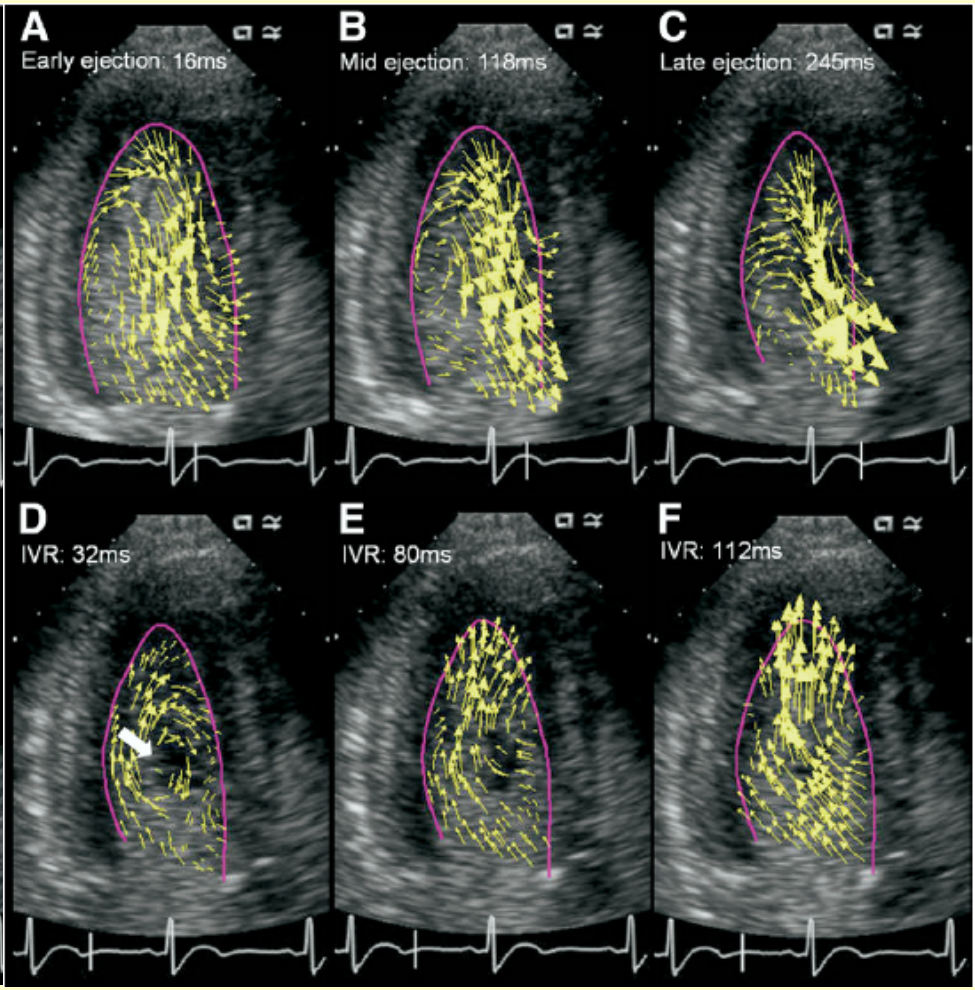

C
IVR


D
Early
Diastole

Ejection

Suction


A
Early diastole: 16ms
B
Diastasis: 142ms
C
Late diastole: 298ms
D
IVC: 16ms
E
IVC: 80ms
F
Ejection: 102ms


A
Early ejection: 16ms
B
Mid ejection: 118ms
C
Late ejection: 245ms
D
IVR: 32ms
E
IVR: 80ms
F
IVR: 112ms

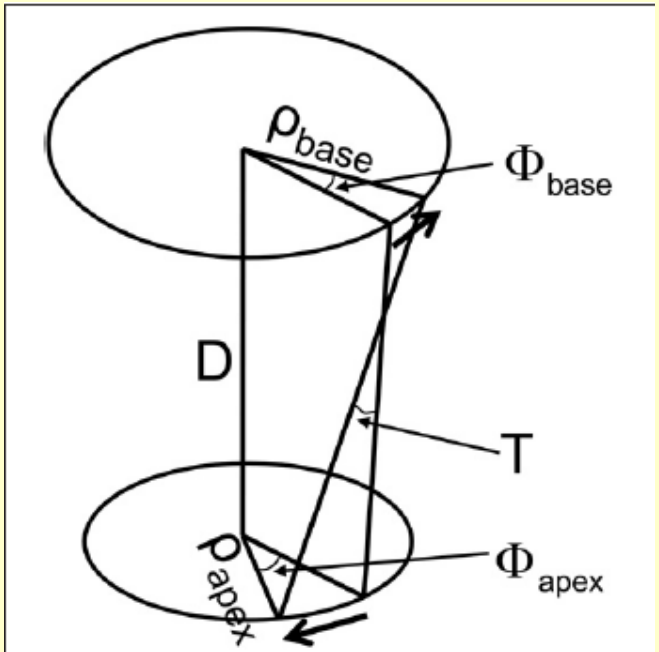


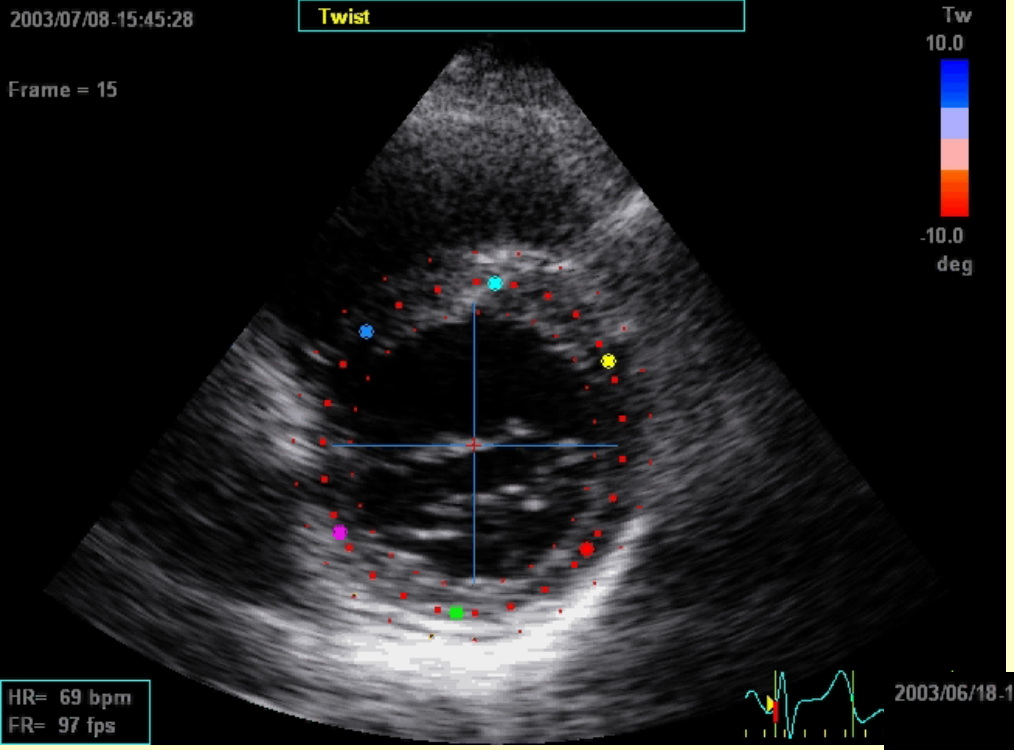
Figure 3. Different Definitions of LV Torsion

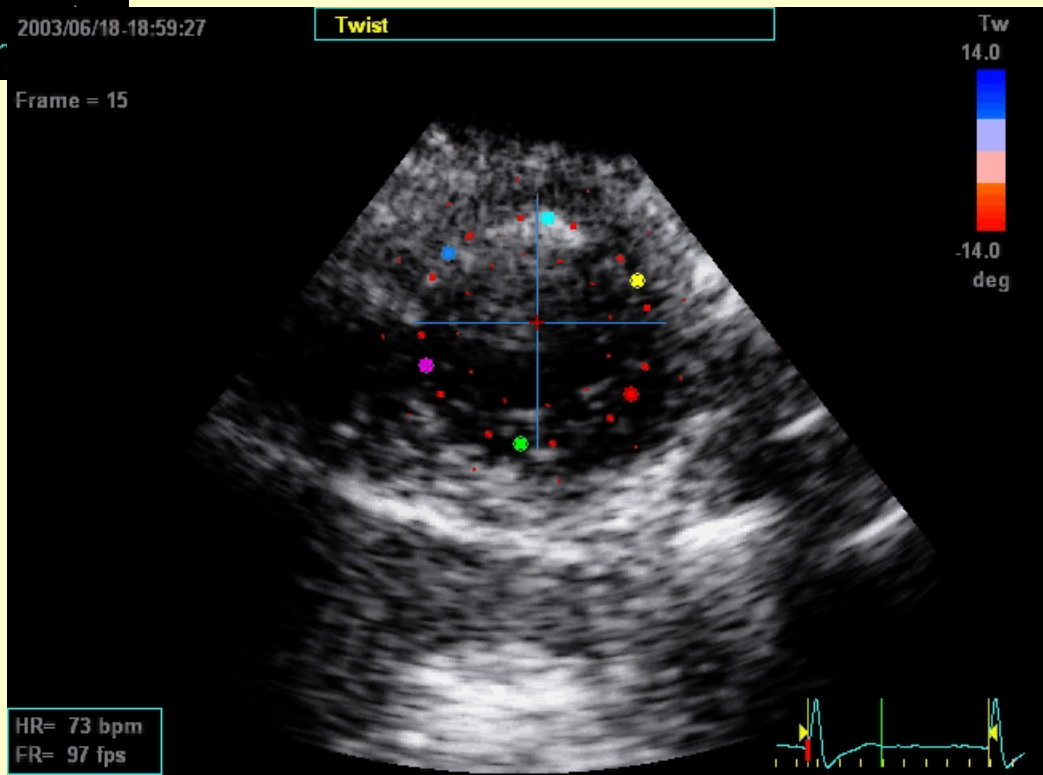
A sketch of a basal and an apical plane and the torsional deformation. Twist is defined as ($\Phi_{apex} - \Phi_{base}$), twist per unit length as ($\Phi_{apex} - \Phi_{base}$)/D, and left ventricle (LV) torsion T (circumferential-longitudinal shear angle) as ($\Phi_{apex} - \Phi_{base}$) ($\rho_{apex} - \rho_{base}$)/2D. Mostly, counterclockwise rotation as seen from the apex is positive.

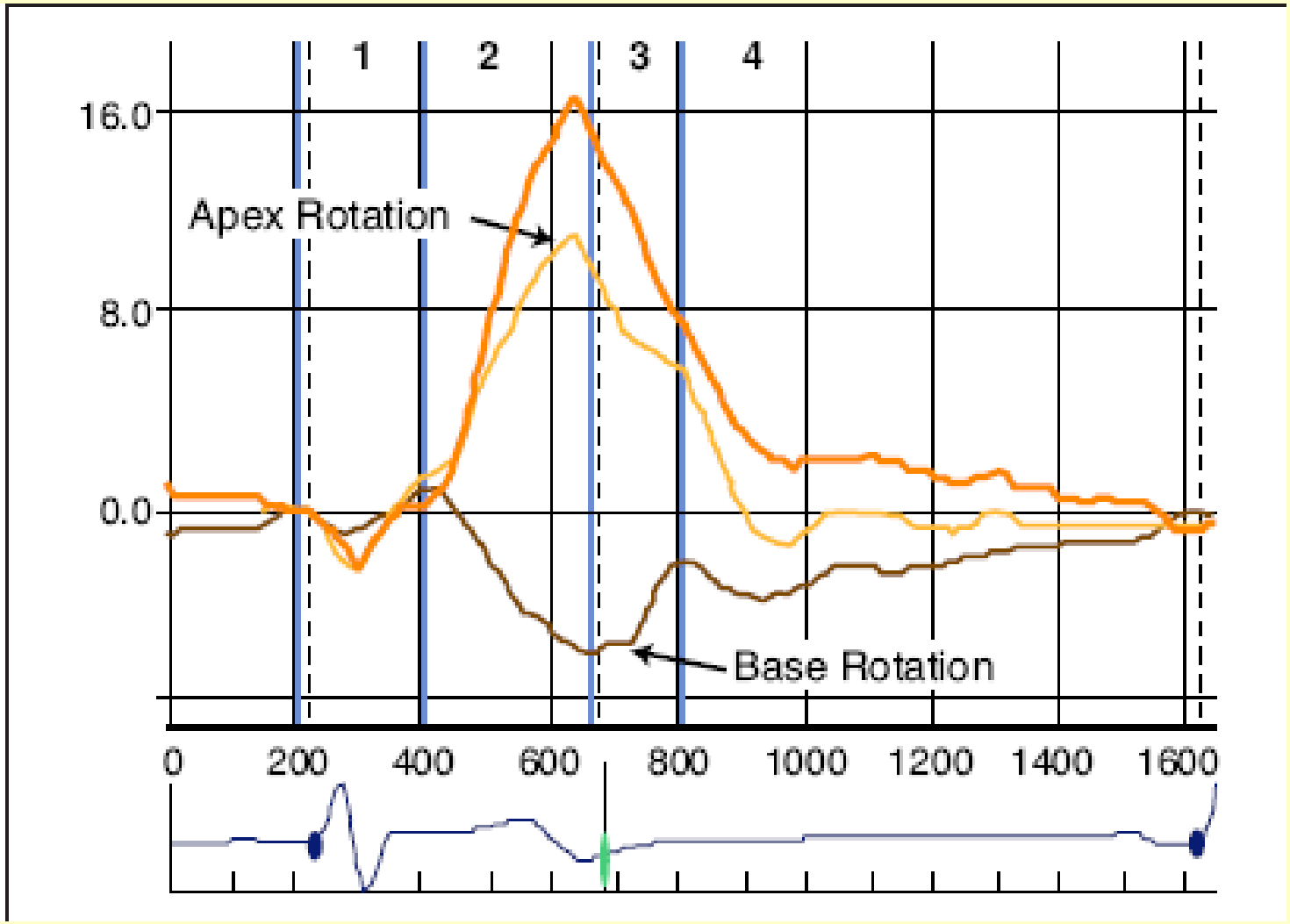
Rotation: περιστροφή επιπέδων στο βραχύ άξονα (μοίρες)

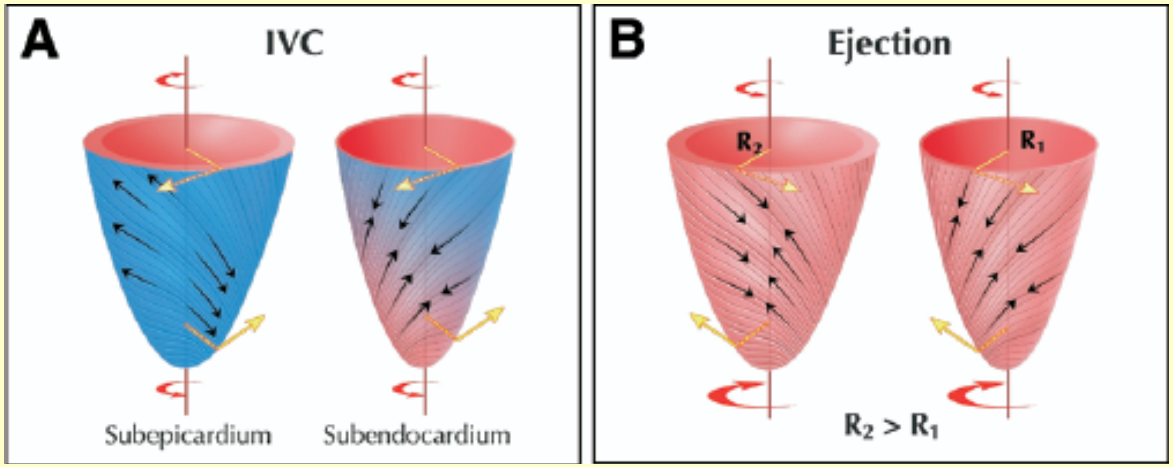
Twist: συνολική διαφορά περιστροφής μεταξύ βάσης και κορυφής (μοίρες)

Torsion: Twist/D


2003/07/08-15:45:28
Twist
Frame = 15
Tw
10.0
-10.0
deg
HR= 69 bpm
FR= 97 fps


2003/06/18-18:59:27
Twist
Frame = 15
Tw
14.0
-14.0
deg
HR= 73 bpm
FR= 97 fps


1
2
3
4
16.0
8.0
0.0
Apex Rotation
Base Rotation
0
200
400
600
800
1000
1200
1400
1600



Αντιωρολογιακή στροφή της βάσης στην παιδική ηλικία

Ωρολογιακή στην εφηβεία

Αύξηση torsion με τη γήρανση με μειωμένο recoil

Table 1. Physiological Variables Influencing Left Ventricular Twist Mechanics

Physiological Variables	Twist	E_r
Increasing preload (35–37)	↑	↓
Increasing afterload (35–37)	↓	↓*
Increasing contractility (9,36,38,39)	↑	↑
Exercise (40)	↑	↑
Increasing age (33,34)	↑	↓*

Numbers in parentheses correspond to the reference number in the References list. *Delayed onset of untwisting.

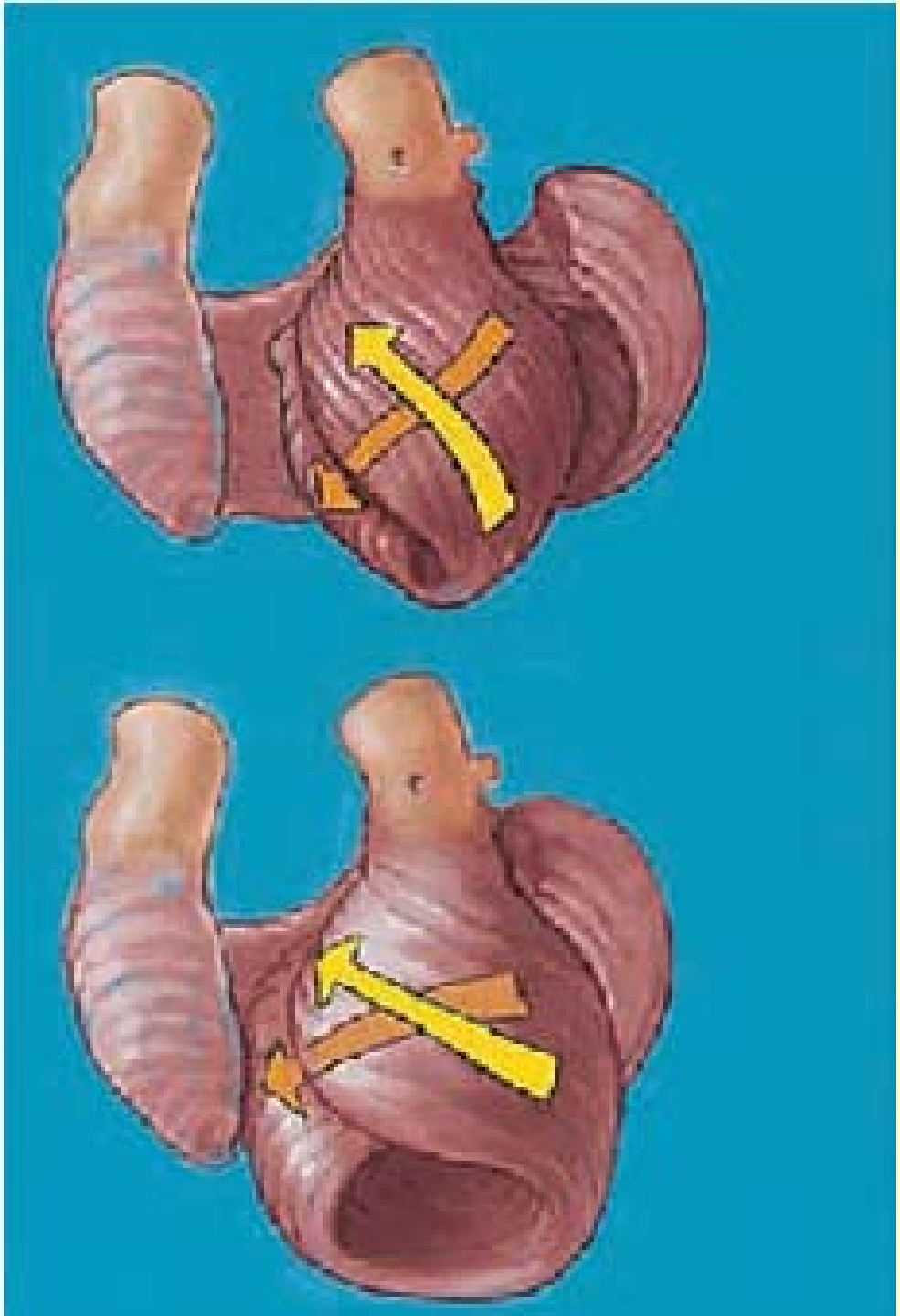
↓ = reduced; ↑ = increased; E_r = early diastolic untwisting velocity.

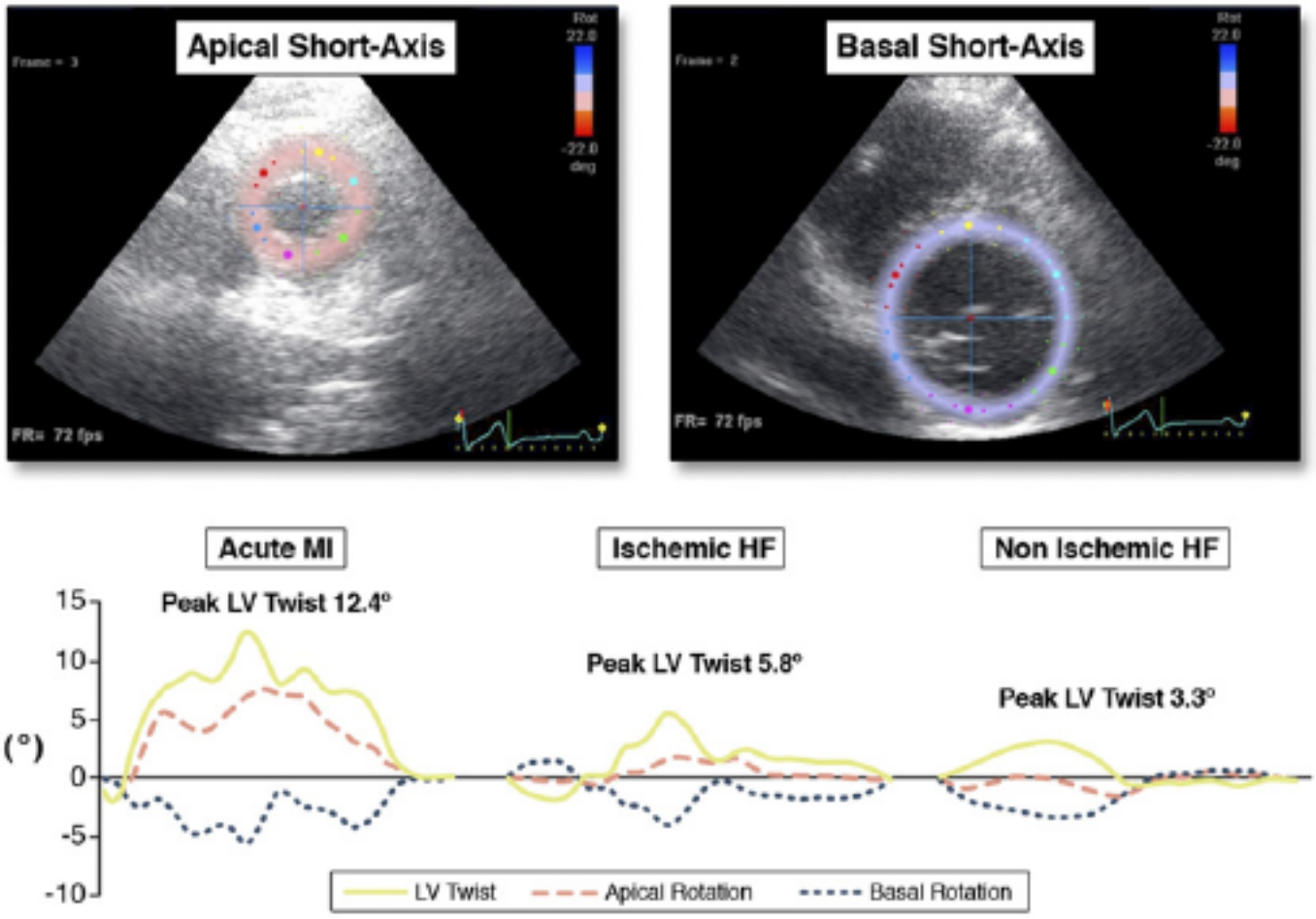
Table 2. Left Ventricular Twist Mechanics in Different Cardiac Diseases

Cardiac Diseases	Twist	E_r
Systolic heart failure	↓	↓
Diastolic heart failure (49,50)	N or ↑	N or ↓
Aortic stenosis (54–56)	N or ↑	↓
Mitral regurgitation (58–60)	↓	↓
Transmural infarction (51)	↓	↓
Subendocardial ischemia	N	N or ↓
Dilated cardiomyopathy (65)	↓	↓
Hypertrophic cardiomyopathy (70,71)	N or ↑	↓
Restrictive cardiomyopathy (73)	N or ↑	N
Constrictive pericarditis (73)	↓	↓

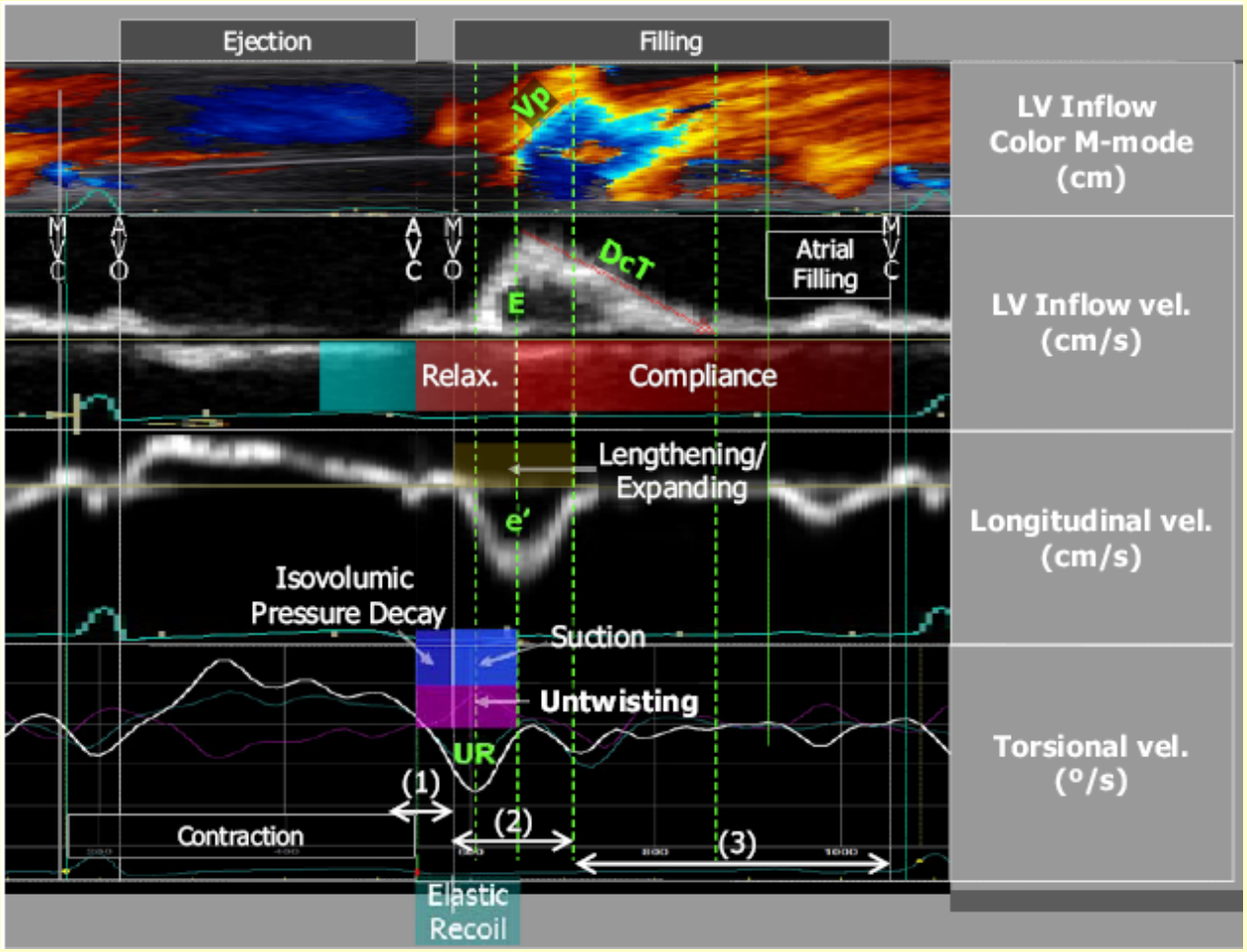
Numbers in parentheses correspond to the reference number in the References list.

↓ = reduced; ↑ = increased; E_r = early diastolic untwisting velocity; N = normal.




Apical Short-Axis
Basal Short-Axis
Acute MI
Ischemic HF
Non Ischemic HF
Peak LV Twist 12.4°
Peak LV Twist 5.8°
Peak LV Twist 3.3°
15
10
5
0
-5
-10
(°)
LV Twist
Apical Rotation
Basal Rotation

Diastology


Ejection
Filling
VP
LV Inflow
Color M-mode
(cm)
MVC
AVO
AVC
MVO
DcT
E
Atrial
Filling
MVC
LV Inflow vel.
(cm/s)
Relax.
Compliance
Lengthening/
Expanding
e'
Longitudinal vel.
(cm/s)
Isovolumic
Pressure Decay
Suction
Untwisting
UR
Torsional vel.
(°/s)
(1)
(2)
(3)
Contraction
Elastic
Recoil

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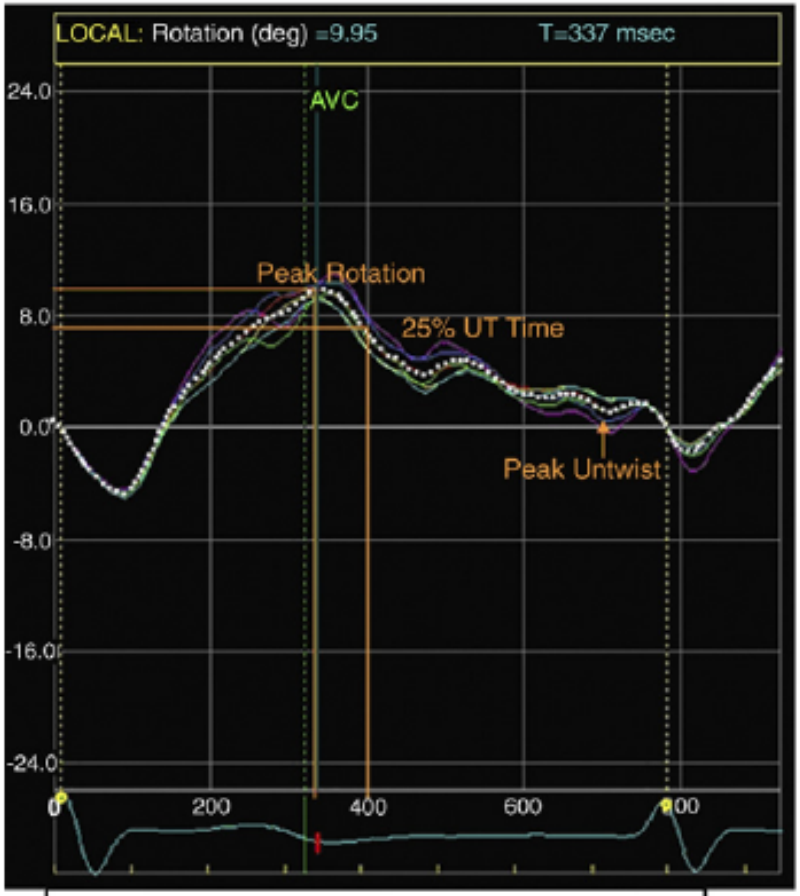
The Pathophysiology of Heart Failure With Normal Ejection Fraction

Exercise Echocardiography Reveals Complex Abnormalities of Both Systolic and Diastolic Ventricular Function Involving Torsion, Untwist, and Longitudinal Motion

Yu Ting Tan, MBBS,* Frauke Wenzelburger, MD,*† Eveline Lee, MBChB,† Grant Heatlie, MBBS, PhD,† Francisco Leyva, MD,* Kiran Patel, MBBChir, PhD,* Michael Frenneaux, MD,* John E. Sanderson, MD*

Birmingham and Stoke-on-Trent, United Kingdom

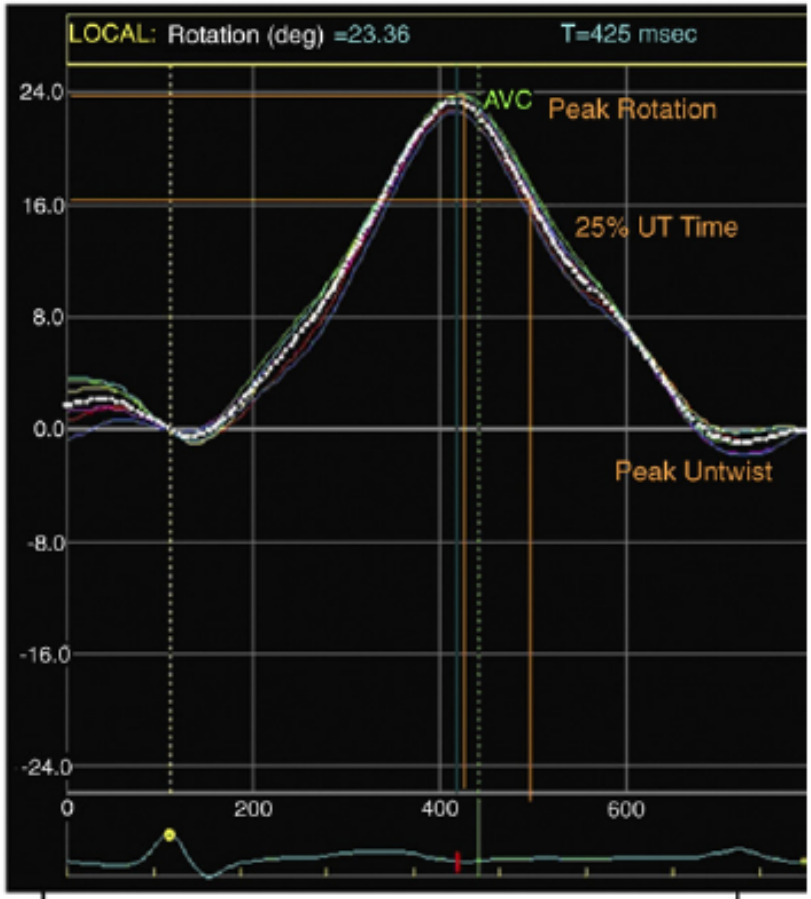
Patient, ♂ 62 years



Peak Rotation: 9.95 " (337ms)

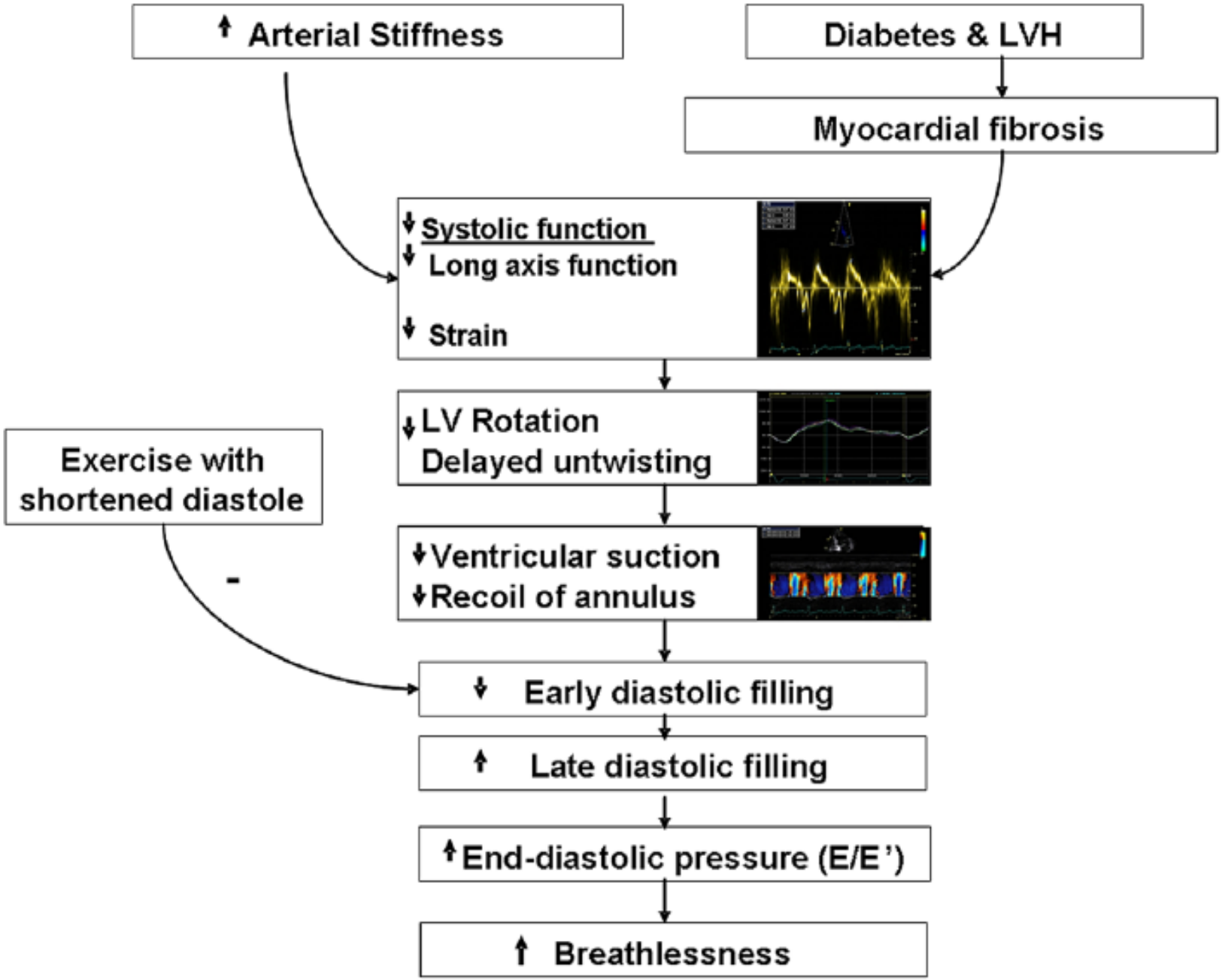
Untwist at 25% of Untwist Duration: 9.25 = 7% (378ms)

Control, ♀ 61 years



Peak Rotation: 23.36 " (at 425ms)

Untwist at 25% of Untwist Duration: 16.88 = 28% (491ms)


↑ Arterial Stiffness
Diabetes & LVH
Myocardial fibrosis
↓ Systolic function
↓ Long axis function
↓ Strain
↓ LV Rotation
Delayed untwisting
Exercise with shortened diastole
-
↓ Ventricular suction
↓ Recoil of annulus
↓ Early diastolic filling
↑ Late diastolic filling
↑ End-diastolic pressure (E/E')
↑ Breathlessness

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Left Ventricular Untwisting Is an Important Determinant of Early Diastolic Function

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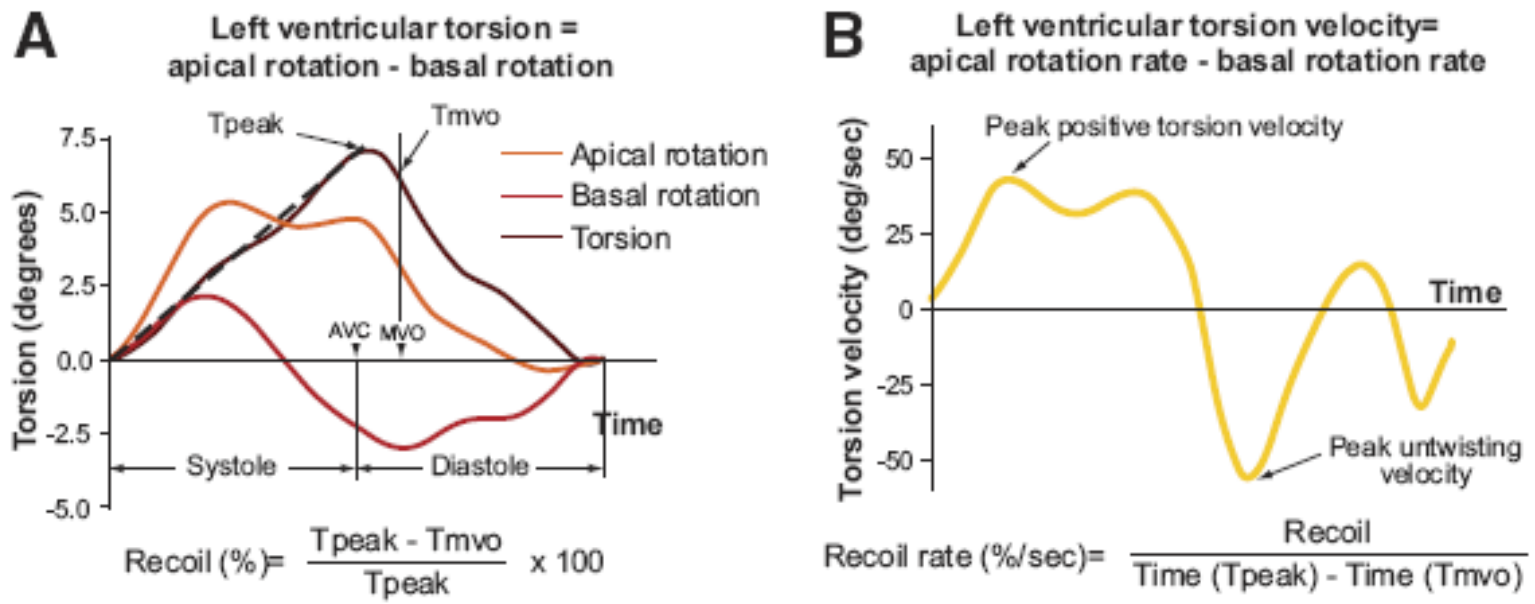
David L. Prior, MBBS, PhD,*† Andrew I. MacIsaac, MBBS, MD*†

Melbourne, Victoria, Australia


A
Left ventricular torsion =
apical rotation - basal rotation
Tpeak
Tmvo
Apical rotation
Basal rotation
Torsion
Torsion (degrees)
7.5
5.0
2.5
0.0
-2.5
-5.0
AVC
MVO
Time
Systole
Diastole
Recoil (%)= Tpeak - Tmvo / Tpeak x 100
B
Left ventricular torsion velocity=
apical rotation rate - basal rotation rate
Peak positive torsion velocity
Torsion velocity (deg/sec)
50
25
0
-25
-50
Time
Peak untwisting
velocity
Recoil rate (%/sec)= Recoil / Time (Tpeak) - Time (Tmvo)

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DOI:10.1016/J.Jcmg.2007.10.006

Disparate Patterns of Left Ventricular Mechanics Differentiate Constrictive Pericarditis From Restrictive Cardiomyopathy

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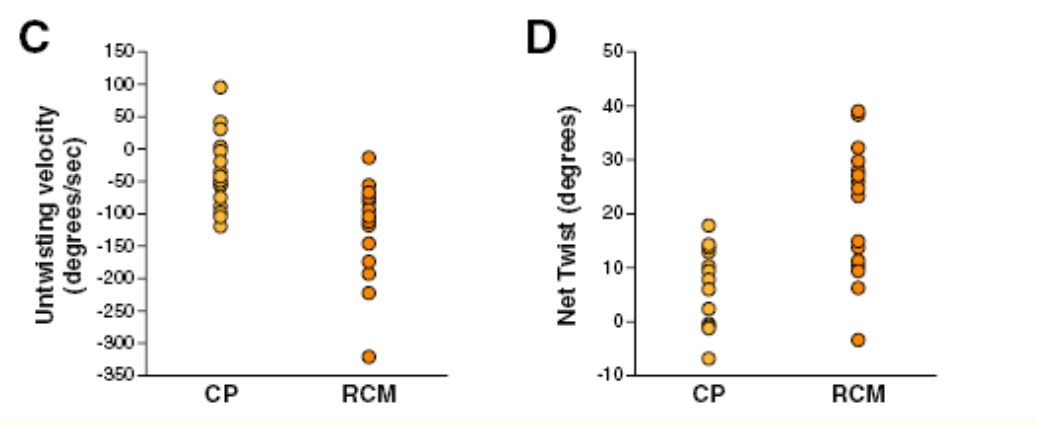
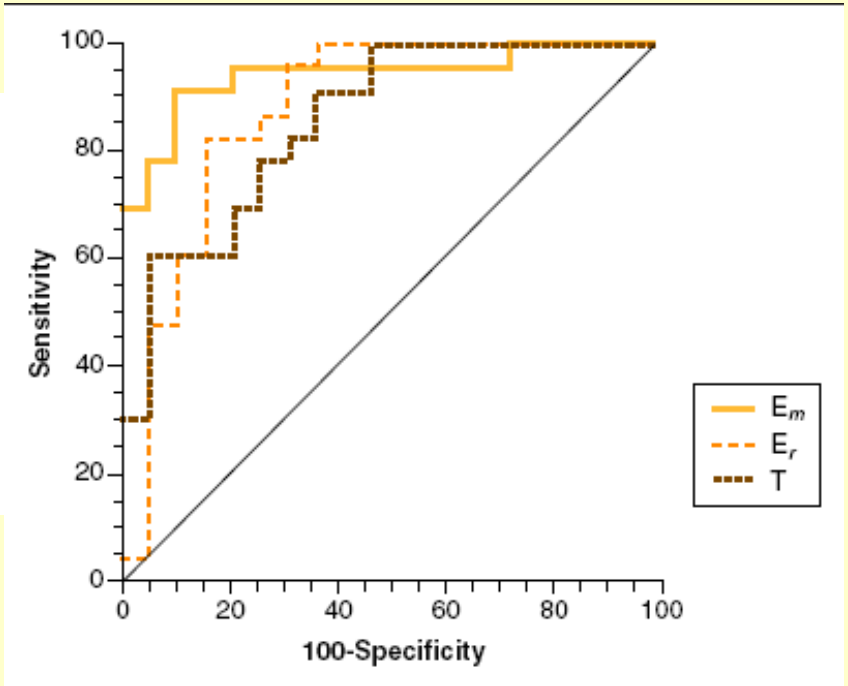
Scottsdale, Arizona; and Rochester, Minnesota





STATE-OF-THE-ART PAPER

Role of Left Ventricular Twist Mechanics in the Assessment of Cardiac Dyssynchrony in Heart Failure

Matteo Bertini, MD,*† Partho P. Sengupta, MBBS, MD, DM,‡ Gaetano Nucifora, MD,* Victoria Delgado, MD,* Arnold C. T. Ng, MBBS,* Nina Ajmone Marsan, MD,* Miriam Shanks, MD,* Rutger R. J. van Bommel, MD,* Martin J. Schalij, MD, PHD,* Jagat Narula, MD, PHD,§ Jeroen J. Bax, MD, PHD*

Leiden, the Netherlands; Bologna, Italy; Scottsdale, Arizona; and Irvine, California

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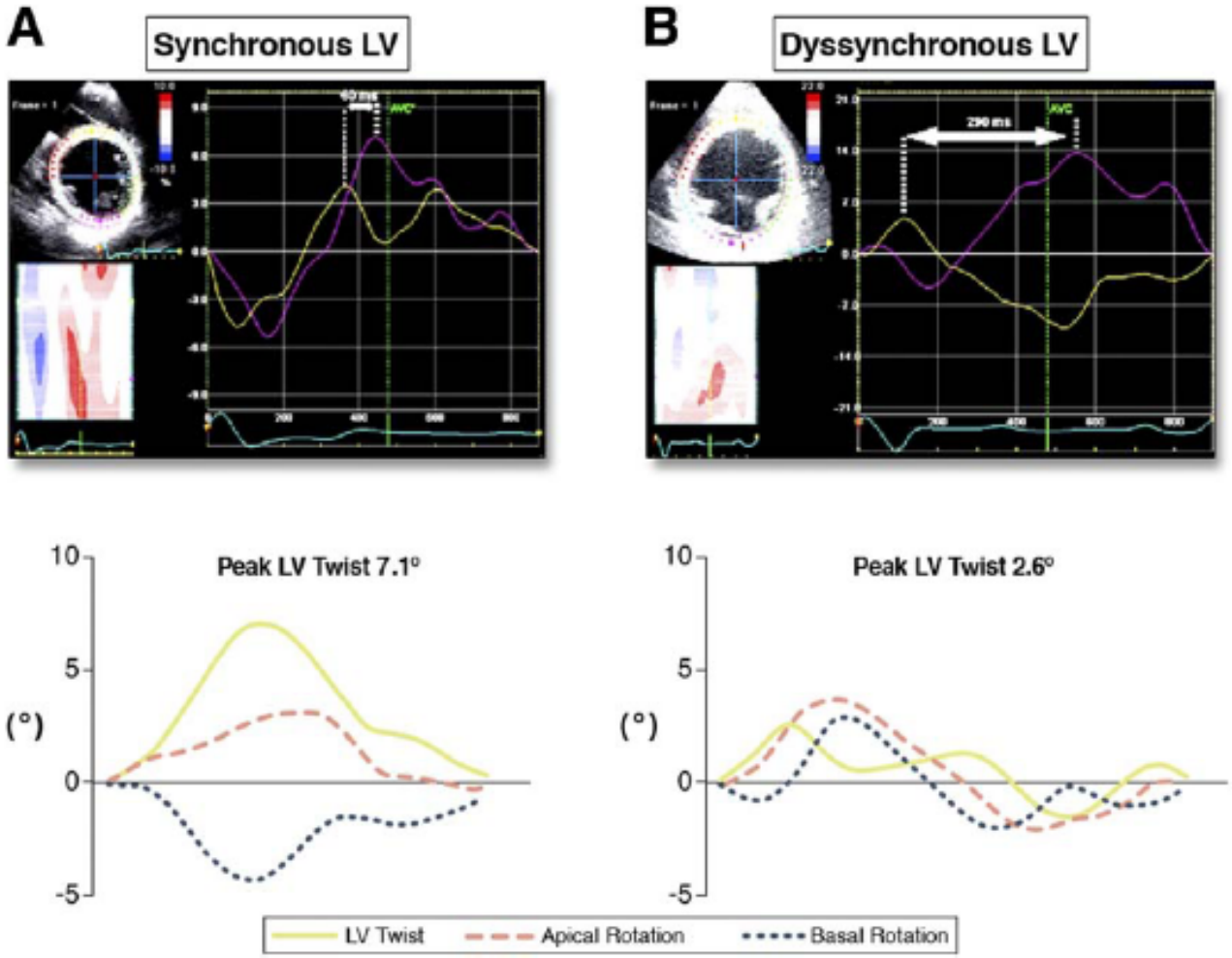
The authors discuss an incremental value of assessing left ventricular (LV) twist mechanics in patients with heart failure (HF) and its potential usefulness in characterizing response to cardiac resynchronization therapy (CRT) and reversal of LV remodeling at 6 months follow-up. They also underscore a critical relationship between LV lead position and changes in LV twist after CRT, and suggest that the reversal of LV remodeling in HF patients following CRT primarily results from restoration of the global sequence of LV twist mechanics. (J Am Coll Cardiol Img 2009;2:1425–35)


A
Synchronous LV
B
Dyssynchronous LV
290 ms
AVC
Peak LV Twist 7.1°
Peak LV Twist 2.6°
10
5
0
-5
(°)
LV Twist
Apical Rotation
Basal Rotation

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Effects of Cardiac Resynchronization Therapy on Left Ventricular Twist

Matteo Bertini, MD,*† Nina Ajmone Marsan, MD,* Victoria Delgado, MD,*
Rutger J. van Bommel, MD,* Gaetano Nucifora, MD,* C. Jan Willem Borleffs, MD,*
Giuseppe Boriani, MD, PHD,† Mauro Biffi, MD,† Eduard R. Holman, MD, PHD,*
Ernst E. van der Wall, MD, PHD,*‡ Martin J. Schalij, MD, PHD,* Jeroen J. Bax, MD, PHD*

Leiden and Utrecht, the Netherlands; and Bologna, Italy

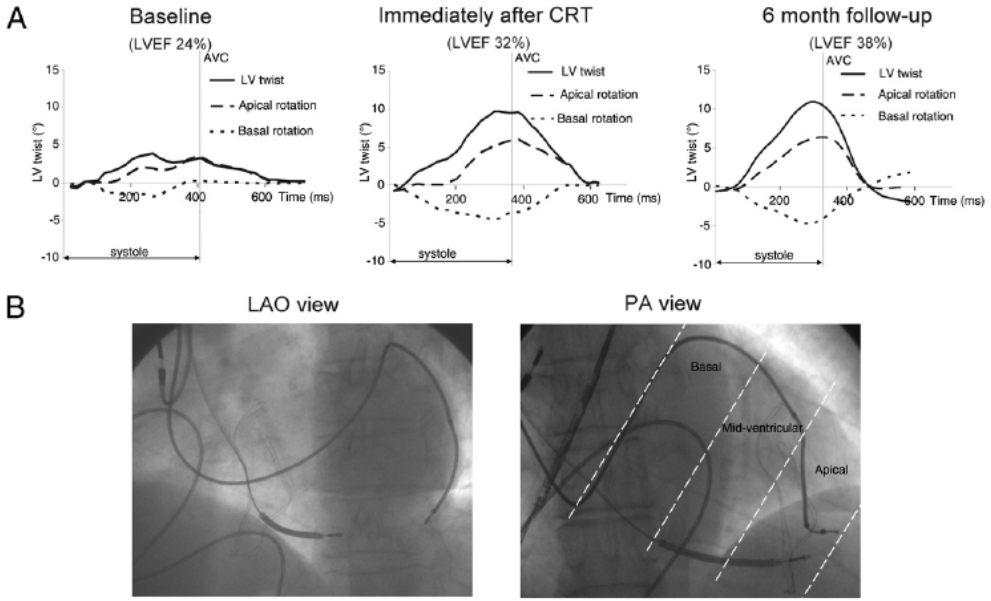
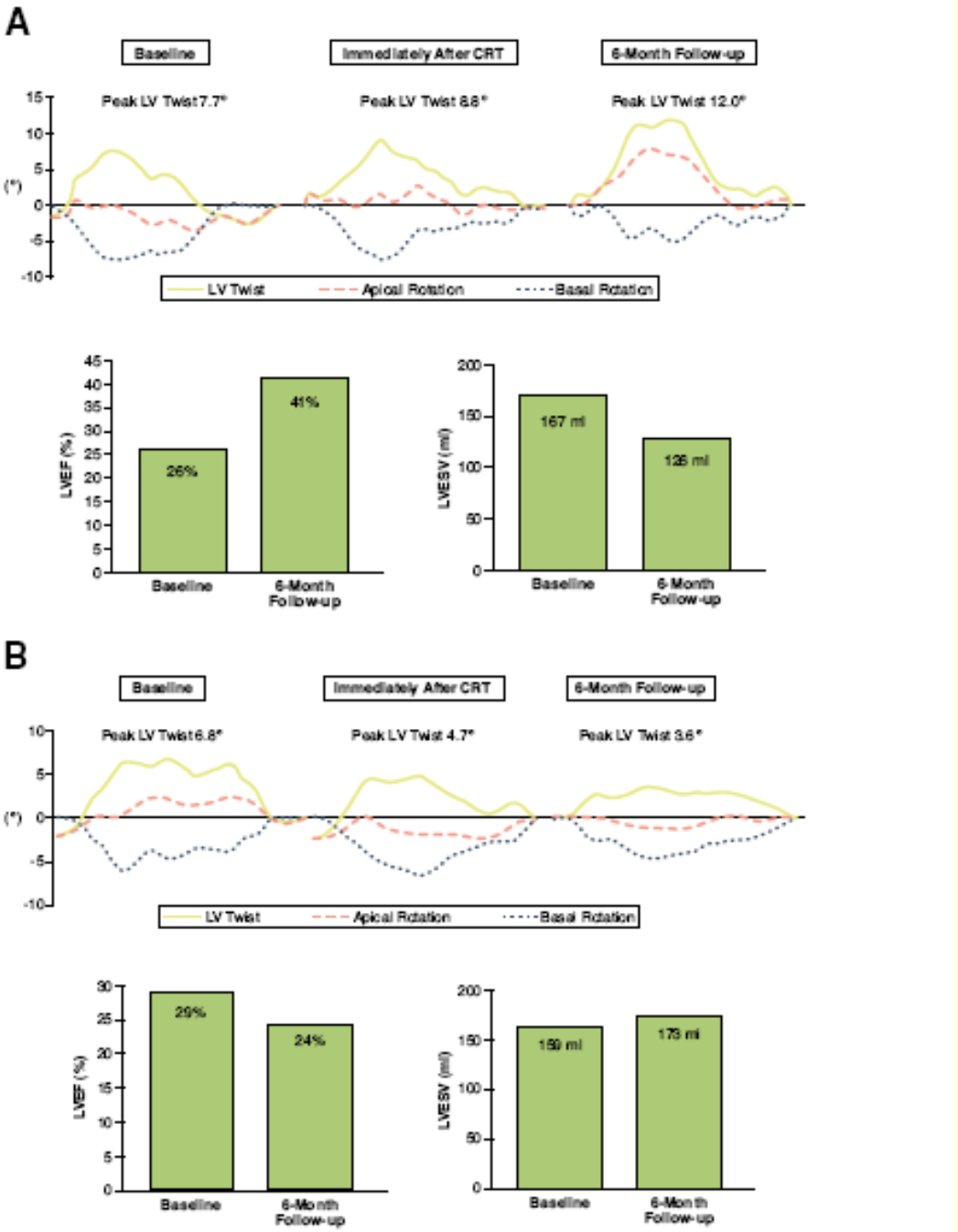
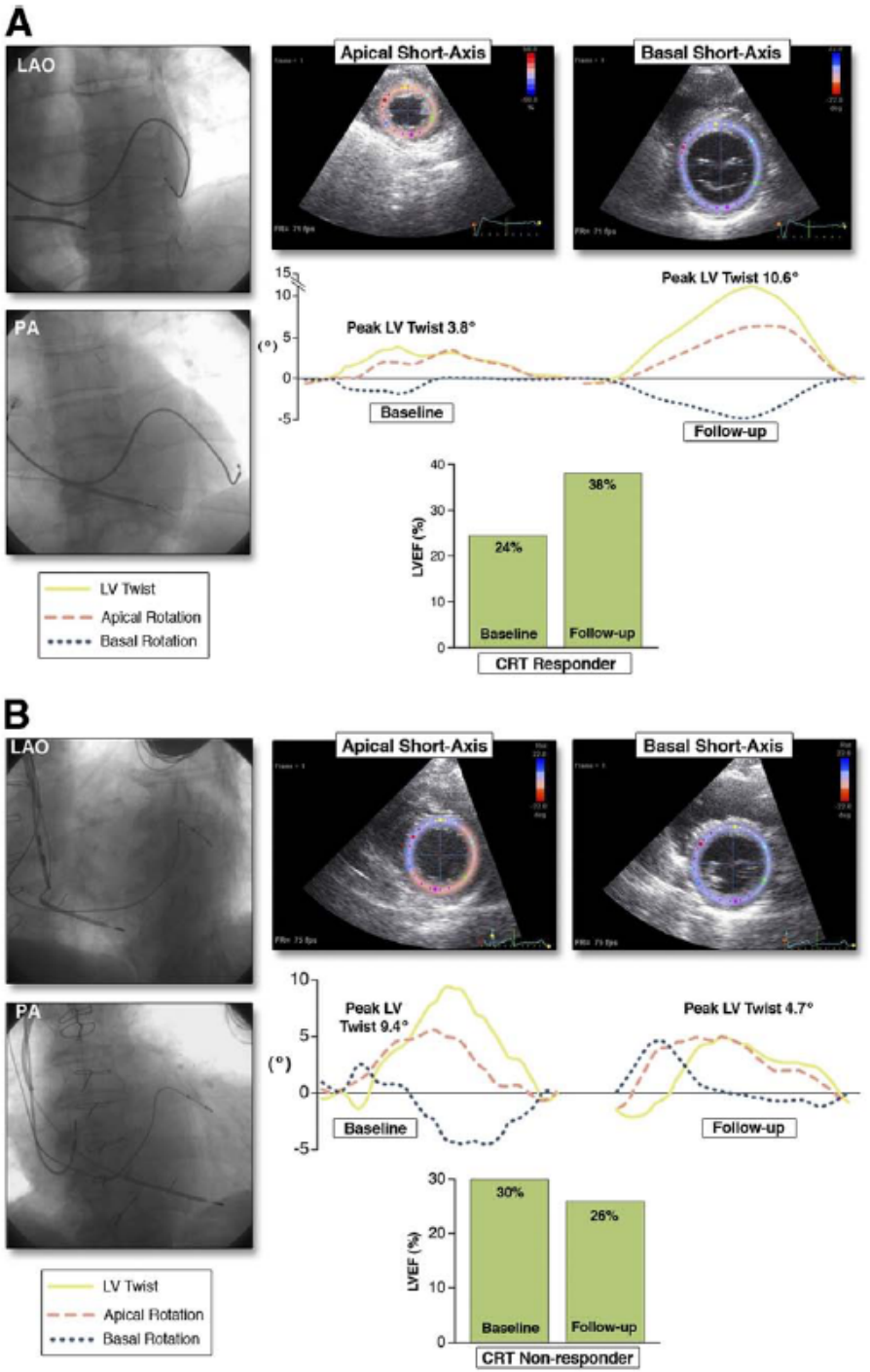


Figure 5 Example of a CRT Responder With LV Lead in an Apical Position

(A) Peak LV twist improved from 3.9° at baseline to 9.7° immediately after cardiac resynchronization therapy (CRT) implantation. Peak LV twist further improved at 6-month follow-up (peak LV twist 10.9°). **(B)** Biplane fluoroscopy: the left anterior oblique (LAO) view shows the LV lead in a posterolateral cardiac vein; in the postero-anterior (PA) view, the distance between the coronary sinus/mitral plane and the cardiac apex was divided **(dotted lines)** into 3 parts (basal, midventricular, and apical). LVEF = left ventricular ejection fraction; other abbreviations as in Figure 1.


A
Baseline
Immediately After CRT
6-Month Follow-up
Peak LV Twist 7.7°
Peak LV Twist 8.8°
Peak LV Twist 12.0°
(°)
LV Twist
Apical Rotation
Basal Rotation
LVEF (%)
26%
41%
Baseline
6-Month Follow-up
LVESV (ml)
167 ml
126 ml
Baseline
6-Month Follow-up
B
Baseline
Immediately After CRT
6-Month Follow-up
Peak LV Twist 6.8°
Peak LV Twist 4.7°
Peak LV Twist 3.6°
(°)
LV Twist
Apical Rotation
Basal Rotation
LVEF (%)
29%
24%
Baseline
6-Month Follow-up
LVESV (ml)
159 ml
173 ml
Baseline
6-Month Follow-up


A
LAO
PA
Apical Short-Axis
Basal Short-Axis
Peak LV Twist 3.8°
Peak LV Twist 10.6°
(°)
Baseline
Follow-up
LV Twist
Apical Rotation
Basal Rotation
LVEF (%)
24%
38%
Baseline
Follow-up
CRT Responder
B
LAO
PA
Apical Short-Axis
Basal Short-Axis
Peak LV Twist 9.4°
Peak LV Twist 4.7°
(°)
Baseline
Follow-up
LV Twist
Apical Rotation
Basal Rotation
LVEF (%)
30%
26%
Baseline
Follow-up
CRT Non-responder

STATE-OF-THE-ART PAPER

Left Ventricular Torsion

An Expanding Role in the Analysis of Myocardial Dysfunction

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During left ventricular (LV) torsion, the base rotates in an overall clockwise direction and the apex rotates in a counterclockwise direction when viewed from apex to base. LV torsion is followed by rapid untwisting, which contributes to ventricular filling. Because LV torsion is directly related to fiber orientation, it might depict subclinical abnormalities in heart function. Recently, ultrasound speckle tracking was introduced for quantification of LV torsion. This fast, widely available technique may contribute to a more rapid introduction of LV torsion as a clinical tool for detection of myocardial dysfunction. However, knowledge of the exact function and structure of the heart is fundamental for understanding the value of LV torsion. LV torsion has been investigated with different measurement methods during the past 2 decades, using cardiac magnetic resonance as the gold standard. The results obtained over the years are helpful for developing a standardized method to quantify LV torsion and have facilitated the interpretation and value of LV torsion before it can be used as a clinical tool. (J Am Coll Cardiol Img 2009;2:648–55)

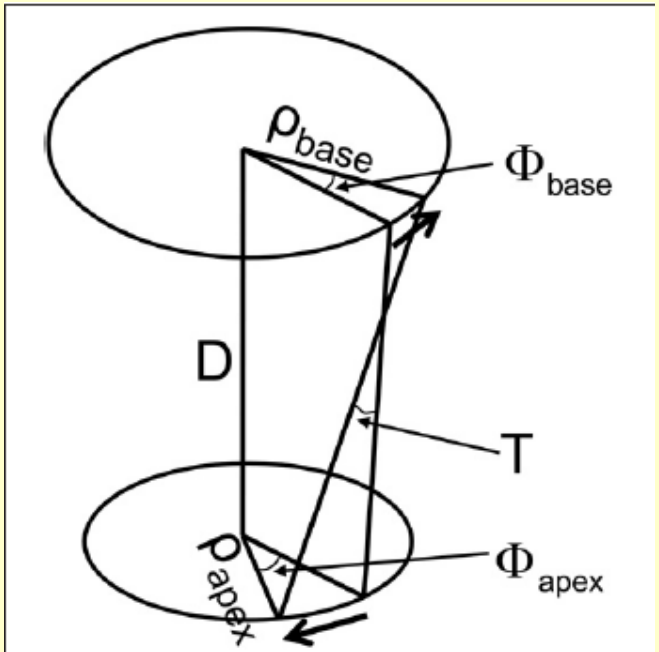

Figure 3. Different Definitions of LV Torsion

A sketch of a basal and an apical plane and the torsional deformation. Twist is defined as ($\Phi_{apex} - \Phi_{base}$), twist per unit length as ($\Phi_{apex} - \Phi_{base}$)/D, and left ventricle (LV) torsion T (circumferential-longitudinal shear angle) as ($\Phi_{apex} - \Phi_{base}$) ($\rho_{apex} - \rho_{base}$)/2D. Mostly, counterclockwise rotation as seen from the apex is positive.

$$T = \frac{(\phi_{apex} - \phi_{base}) \times (\rho_{apex} + \rho_{base})}{2D}$$

TransDif= Torsion/shortening

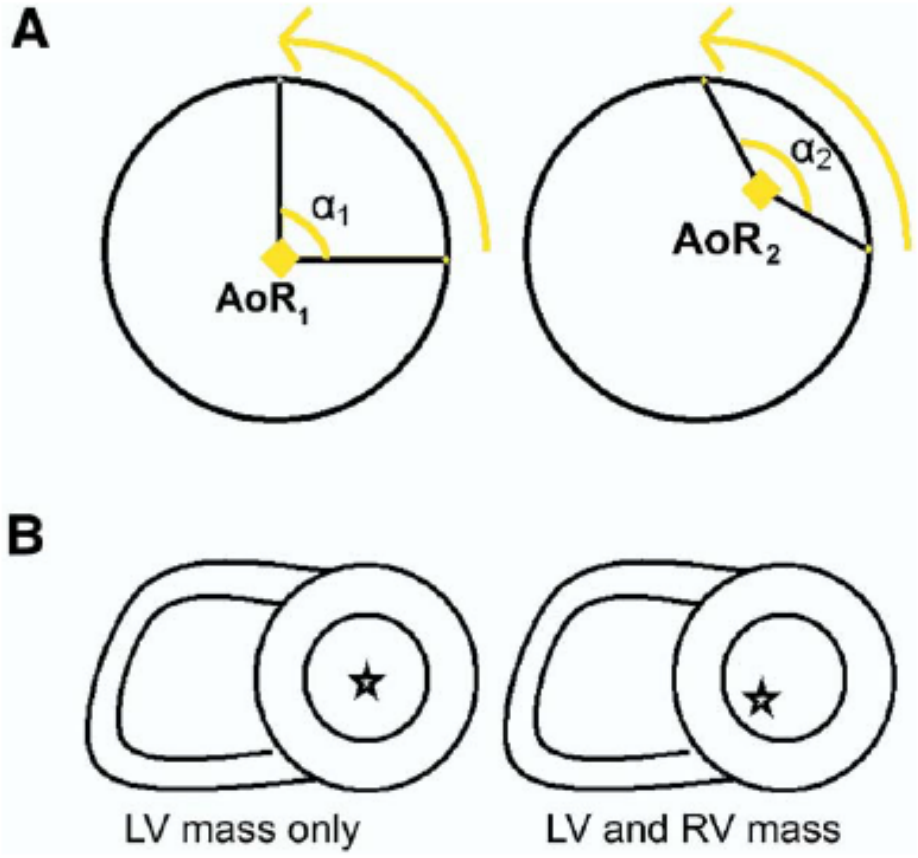

Figure 4. Effect of a Displaced AoR on Measured Rotation

A displaced AoR results in a different observed rotation angle for the same displacement (**A**). Inclusion of the RV mass in the calculation of the AoR will move the AoR more toward inferoseptal (**B**). Reprinted from Rüssel et al. (18), with permission from Biomed Central. AoR = axis of rotation; LV = left ventricle; RV = right ventricle.

MRI?

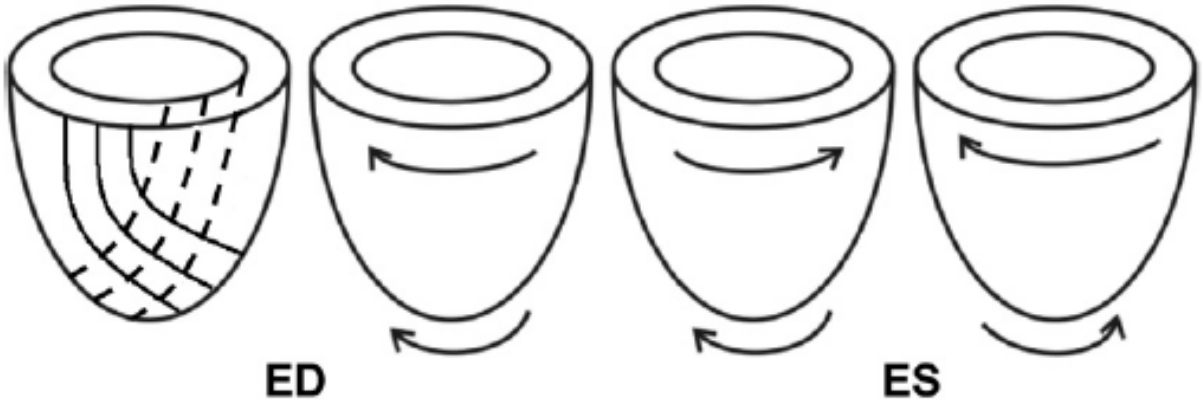

Figure 1. Schematic Drawing of LV Torsion

The **image on the left** shows the myofiber directions. **Solid lines** = epicardial region; **dashed lines** = endocardial region. The **image on the right** shows untwisting. ED = end-diastole; ES = end-systole; LV = left ventricle.

MRI?

Table 1. Reference Values for LV Torsion and Its Timing Between Base and Apex, Base and Mid, and Mid and Apex Levels in 12 Healthy Subjects, Calculated as the Circumferential-Longitudinal Shear Angle Using CMR Tagging

	Base-Apex	Base-Mid	Mid-Apex
Peak torsion, degrees	7.7 ± 1.4	8.2 ± 2.3	8.1 ± 1.1
Time-to-peak torsion, ms	366 ± 24	357 ± 33	370 ± 28

Adapted from Rüssel et al. (18).
LV = left ventricle; CMR = cardiac magnetic resonance.

The known and the unknown

- As we know, there are known knowns-there are things we know we know. We also know there are known unknowns-that is to say we know there are some things we do not know. But there are also unknown unknowns-the ones we don't know we don't know.

  - Donald H. Ramsfeld, US secretary of defense Dept. of Defense news briefing 12-02-2002