ΔΙΑΓΝΩΣΗ ΚΑΙ ΠΑΡΑΚΟΛΟΥΘΗΣΗ ΜΥΟΚΑΡΔΙΑΚΗΣ ΔΥΣΛΕΙΤΟΥΡΓΙΑΣ.

ΤΟ ΛΥΚΟΦΩΣ Ή Η ΓΕΝΕΣΗ ΤΗΣ ΣΥΓΧΡΟΝΗΣ ΗΧΩΚΑΡΔΙΟΓΡΑΦΙΑΣ?

ΩΝΑΣΕΙΟ ΚΑΡΔΙΟΧΕΙΡΟΥΡΓΙΚΟ ΚΕΝΤΡΟ
Transthoracic Echocardiography Accreditation Committee
European Association Cardiovascular Imaging
ΛΥΚΟΦΩΣ Ή ΑΝΑΤΟΛΗ ??
Η ΕΞΕΛΙΞΗ ΔΙΝΕΙ ΤΗΝ ΑΠΑΝΤΗΣΗ
Length - Force relation

Cardiac Muscle Isometric Contractions

Active Tension

Force Transducer

Increased Preload

1.6 µ  2.2 µ

Sarcomere Length

(RK '17)

SL 1.65 µm

SL 2.15 µm

(Ca²⁺)i

360 msec

F

0

48

0
Pressure - Volume loop

Positive inotropic effect

β-adrenergic

Control

Lusitropic

VENTRICULAR PRESSURE

VENTRICULAR VOLUME
LV Ventriculography

(A) Diastole - Systole

(B) Diastole - Systole
ΗΧΩΚΑΡΔΙΟΓΡΑΦΙΚΗ ΜΕΘΟΔΟΣ ΕΚΤΙΜΗΣΗΣ ΣΥΣΤΟΛΙΚΗΣ ΛΕΙΤΟΥΡΓΙΑΣ Α.Κ.

- ΕΥΚΟΛΑ ΠΡΟΣΒΑΣΙΜΗ & ΕΦΑΡΜΟΣΙΜΗ
- ΑΚΙΝΔΥΝΗ
- ΧΑΜΗΛΟΥ ΚΟΣΤΟΥΣ
- ΕΠΑΝΑΛΗΨΙΜΗ
- ΣΥΝΤΟΜΗΣ ΔΙΑΡΚΕΙΑΣ
- ΥΨΗΛΗΣ ΔΙΑΓΝΩΣΤΙΚΗΣ ΑΞΙΑΣ !!!!
Εκτίμηση Ογκών - Κλάσματος Εξώθησης ΑΚ

Υπερπηδά προβλήματα γεωμετρικών παραδοχών και παραμορφώσεων της κοιλότητος
** Στηρίζεται σε 2 τομές
** Σημαντική η εμπειρία του εξεταστή
CARDIAC MRI VOLUMES & MASS MEASUREMENTS

Diastole

Systole

Left Ventricular Volume Results

<table>
<thead>
<tr>
<th></th>
<th>Normal (reference)</th>
<th>Indexed values (by Body Surface Area)</th>
<th>Normal (reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass:</td>
<td>341.16 g</td>
<td>141.16 g/m²</td>
<td>46 - 84</td>
</tr>
<tr>
<td>ED volume:</td>
<td>381.74 ml</td>
<td>157.95 ml/m²</td>
<td>52 - 112</td>
</tr>
<tr>
<td>ES volume:</td>
<td>167.85 ml</td>
<td>69.45 ml/m²</td>
<td>-</td>
</tr>
<tr>
<td>Stroke volume:</td>
<td>213.89 ml</td>
<td>88.50 ml/m²</td>
<td>-</td>
</tr>
<tr>
<td>Ejection fraction:</td>
<td>56.03 %</td>
<td>Cardiac output index:</td>
<td>8.16 l/(min·m²)</td>
</tr>
<tr>
<td>Cardiac output:</td>
<td>19.72 l/min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

João L. Cavalcante. JACC CVInterv 2016:39;99 - 425
COMPARISON OF LEFT VENTRICULAR EJECTION FRACTION AND VOLUMES IN HEART FAILURE

<table>
<thead>
<tr>
<th>Method</th>
<th>LV end-diastolic volume</th>
<th>LV end-systolic volume</th>
<th>EF by Simpson’s biplane</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D echo</td>
<td>36</td>
<td>136 ± 51 ml</td>
<td>98 ± 37 ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>RNV</td>
<td>51</td>
<td>24 ± 21%</td>
<td></td>
</tr>
<tr>
<td>CMR</td>
<td>52</td>
<td>267 ± 106 ml</td>
<td>192 ± 98 ml</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52</td>
<td>30 ± 9%</td>
</tr>
</tbody>
</table>

CHRISTMAS Study Eur Heart J 2000; 21: 1387-1396
LV Opacification
Global volume-time curve is obtained, which displays the dynamic course of the global volume change during the cardiac cycle.

The accuracy of the technique has been largely validated against cardiac MRI.

Jenkins CJ Am Coll Cardiol 2004;44:878-886
Jacobs LD Eur Heart J 2006; 27:460-468
LEFT VENTRICULAR SYSTOLIC FUNCTION HAEMODYNAMIC INDEXES

\[
dP/dt = \frac{32}{0.029} = 1103 \text{ mmHg/sec}
\]

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mmHg</td>
<td>1 m/sec</td>
</tr>
<tr>
<td>36 mmHg</td>
<td>3 m/sec</td>
</tr>
</tbody>
</table>

\[
dP/dt = \frac{\Delta P}{\Delta t} = \frac{36 - 4 \text{ mmHg}}{\Delta t} = \frac{32 \text{ mmHg}}{\Delta t (sec)}
\]
Myocardial fibre shortening: 15%
Myocardial fibre thickening: 8%

LV geometry

LV end-diastolic volume
LV end-systolic volume

Intrasarcomeric cytoskeleton
Extracellular matrix
Extrasarcomeric cytoskeleton
Non-contractile myocardial components

LV ejection fraction: ~60%

Myocardial fibre at end-diastole
Myocardial fibre at end-systole
L.V. GEOMETRY AS A MAJOR DETERMINANT OF L.V. EJECTION FRACTION

A
Longitudinal fibres

15% fibre shortening

EF=15%

B
Circumferential fibres

15% fibre shortening

EF=30%

C
Spiral fibres

15% fibre shortening

EF≥60%
DEFORMATION IMAGING

Motion
- Radial motion
- Longitudinal motion

Deformation
- Circumferential shortening
- Rotation
- (Longitudinal) thickening
- (Radial) thickening

Velocity → Displacement

Strain Rate → Strain

Apical
- MVO
- AVC

Septum
- MVO
- AVC

4-chamber view
- Basal
**SPECKLE TRACKING STRAIN IMAGING**

Representative Speckle

\[ \text{Strain} = \Delta \text{ length} / \text{original length} \]

- % Thickening (Red Color-Coding)
- % Thinning (Blue Color-Coding)

**Radial Strain (%)**

Frame = 17

Anterior-septal
Inferior-septal
Inferior
Posterior
Lateral
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Peak Systolic Strain (%)</th>
<th>Peak Systolic SR (1/s)</th>
<th>Early Diastolic (E) SR (1/s)</th>
<th>Late Diastolic (A) SR (1/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SEM</td>
<td>-18.6 ± 0.1</td>
<td>-1.10 ± 0.01</td>
<td>1.55 ± 0.01</td>
<td>1.02 ± 0.01</td>
</tr>
<tr>
<td>Lower 95% limit</td>
<td>-18.5</td>
<td>-1.09</td>
<td>1.54</td>
<td>1.01</td>
</tr>
<tr>
<td>Upper 95% limit</td>
<td>-18.7</td>
<td>-1.11</td>
<td>1.56</td>
<td>1.03</td>
</tr>
</tbody>
</table>
NORMAL CONTROL

GLS aver: -22.2%
SEVERE SYSTOLIC - DIASTOLIC LV DYSFUNCTION

GLS aver:-9%
Because ischemic wall motion abnormalities are often associated with passive motion, such as passive expansion and recoil and tethering from adjacent segments…. strain imaging has the advantage of differentiating active contraction from passive motion.

Patients with AS managed conservatively had worsening of GLS over 12 months despite preserved LV EF, detected earliest in the subendocardial layer.
2017 ESC/EACTS GUIDELINES FOR THE MANAGEMENT OF VALVULAR HEART DISEASE
### Recommendations for Cardiac Imaging in Patients with Suspected or Established Heart Failure

#### TTE
- **Class:** I
- **Level:** C

TTE is recommended for the assessment of myocardial structure and function in subjects with suspected HF in order to establish a diagnosis of either HFrEF, HFmrEF, or HFpEF.

- **Class:** I
- **Level:** C

TTE is recommended to assess LVEF in order to identify patients with HF who would be suitable for evidence-based pharmacological and device (ICD, CRT) treatment recommended for HFrEF.

- **Class:** I
- **Level:** C

TTE is recommended for the assessment of valve disease, right ventricular function and pulmonary arterial pressure in patients with an already established diagnosis of either HFrEF, HFmrEF, or HFpEF in order to identify those suitable for correction of valve disease.

- **Class:** I
- **Level:** C

TTE is recommended for the assessment of myocardial structure and function in subjects to be exposed to treatment which potentially can damage myocardium (e.g. chemotherapy).

- **Class:** I
- **Level:** C

Other techniques (including systolic tissue Doppler velocities and deformation indices, i.e. strain and strain rate), should be considered in a TTE protocol in subjects at risk of developing HF in order to identify myocardial dysfunction at the preclinical stage.

- **Class:** IIa
- **Level:** C

### CMR
- **Class:** I
- **Level:** C

CMR is recommended for the assessment of myocardial structure and function (including right heart) in subjects with poor acoustic window and patients with complex congenital heart diseases (taking account of cautions/contra-indications to CMR).

- **Class:** IIa
- **Level:** C

CMR with LGE should be considered in patients with dilated cardiomyopathy in order to distinguish between ischaemic and non-ischaemic myocardial damage in case of equivocal clinical and other imaging data (taking account of cautions/contra-indications to CMR).

- **Class:** I
- **Level:** C

CMR is recommended for the characterization of myocardial tissue in case of suspected myocarditis, amyloidosis, sarcoidosis, Chagas disease, Fabry disease non-compaction cardiomyopathy, and haemochromatosis (taking account of cautions/contra-indications to CMR).

---

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure
European Heart Journal 2016; 37: 2129-2200
Global systolic longitudinal myocardial strain (GLS) has been reported to accurately predict a subsequent decrease in LVEF.

These advanced echocardiographic measurements are preferred, when available, to serve as the basis for clinical decisions when performed with adequate expertise at laboratories doing cardiac safety studies.
SEQUENCE OF TWIST MECHANICS

A
IVC
Subepicardium
Subendocardium

B
Ejection
R₂ > R₁

C
IVR

D
Early Diastole

IVC Eje IVR Diast

Apex Rotation

Base Rotation

J Cardiov Ultrasound 2011

Sengupta et al. JACC 2006
TWIST & TWISTING RATE IN HF

Examples of patients
(A) control group;
(B) HTNGrade2/3;
(C) CMPN-ISC;
GLS and GCS by feature-tracking CMR analysis was a rapid means to obtain myocardial strain similar to speckle-tracking echocardiography.

MYOCARDIAL DYSFUNCTION
AETIOLOGY
CHARACTERIZATION AND QUANTIFICATION OF VORTEX FLOW BY CONTRAST ECHOCARDIOGRAPHY USING VECTOR PARTICLE IMAGE VELOCIMETRY
THE VORTEX
AN EARLY PREDICTOR OF CARDIOVASCULAR OUTCOME?

Vortex: Δίνη    Thrust: Ωθηση    Turbulence: Στροβολισμός

Pedrizzetti G. Nature Reviews Cardiology 2014;11:545-553
Clinical scientists are limited in that they are not afforded total control of the complex interactions that may alter LV performance.

Consequently, one is forced to rely on indices that are not pure in their measurement of LV function.

Clinical Pitfalls

“Nothing is entirely true, but there is some truth in each aspect... We do fairly well with half-truths so long as we remember that there are half-truths.” Dialogues of Alfred North Whitehead (1953, as recorded by Lucian Price)

Boudoulas K. Cardiology 2018;140:257-261
INNOVATIVE IMAGING METHODS IN HEART FAILURE

ECHO
- From 2D to 3D echocardiography
- From ejection fraction to myocardial strain
- From rest to stress assessment of LV function

CMR
- From late gadolinium enhancement to T1/T2 mapping
- From invasive to non-invasive coronary anatomy and perfusion

Imaging innovations: paradigm shifts in cardiac assessment

From morphometry and function to pathogenetic mechanisms

GENETICS

Position statement on behalf of the HFA of ESC
European Journal of Heart Failure 2018
ECHOCARDIOGRAPHY
A VALUABLE CLINICAL TOOL !!

Ambulance
Patients Wards
Emergency Department
Coronary Care Unit
Operating Theater
Intensive Care Unit

...is everywhere !!!
ΛΥΚΟΦΩΣ Ἡ ΑΝΑΤΟΛΗ;

Απεικόνιση: Άνθρωποι σε σκάφη στη θάλασσα, υπό το φως της ανατολής.
Ο ΜΑΡΑΘΩΝΙΟΣ ΤΗΣ ΗΧΩ...ΚΑΡΔΙΟΛΟΓΙΑΣ