

Grundlagen

Funktionsbeurteilung des linken Ventrikels Moderne Verfahren zur Funktionsbeurteilung



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meet-Echokardiographiekurs
26.6.2024



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Conflict of Interest - Disclosure

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed

Affiliation/Financial Relationship	Company
1. Honoraria for lectures	Amicus, Pfizer, AstraZeneca, Bayer, Boehringer Ingelheim, Sanofi, Chiesi, Takeda, BMS, Canon, TomTec, Bracco, Novartis
2. Honoraria for advisory board activities	Alnylam, BMS, Pfizer
3. Participation in clinical trials	AstraZeneca, SMT, Sanofi, Medtronic, Cardiac Dimensions, LivaNova
4. Research funding	Pfizer, Sanofi

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Echo: dinosaur vs super tool?



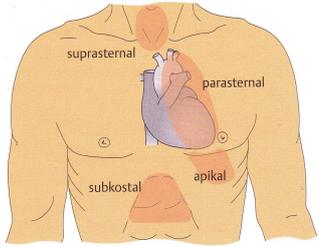

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Worum geht es?

15:00 - 16:20	<p>System 1:</p> <ul style="list-style-type: none"> Grundlagen (Funktionsmessung, Scanning Methoden, Schreibarten) F. Knebel Funktionsbeurteilung des linken Ventrikels (global und regional) F. Knebel Moderne Verfahren/Konzepte zur Funktionsbeurteilung (Strain/Speckle Tracking inkl. Step-by-Step Guide) F. Knebel
16:20 - 16:35	Pause
16:35 - 17:45	<p>System 2:</p> <ul style="list-style-type: none"> Nicht hypertrophe Kardiomyopathie <ul style="list-style-type: none"> Dilatative Kardiomyopathie (DCM) Ischämische Kardiomyopathie (ICM) Seltene Formen z.B. Arrhythmogene Kardiomyopathie (ACM) F. Knebel Hypertrophe Kardiomyopathie inkl. Differenzialdiagnose <ul style="list-style-type: none"> Linksherzhypertrophie („Echte“ HCM) Spezialform Infiltrative Kardiomyopathien (Amyloidose, Mucopolysaccharidose, etc.) F. Knebel
17:45 - 17:55	Lehrerfolgskontrolle Ende der Veranstaltung

4

Schallfenster



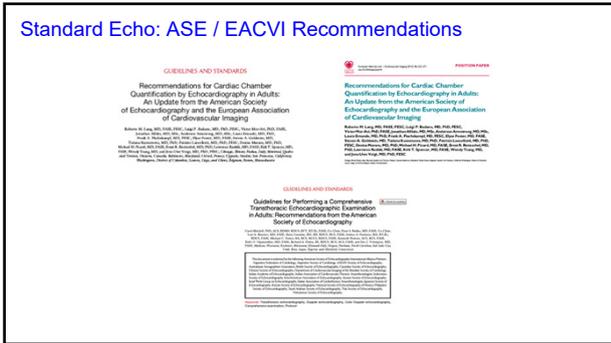
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Patient vorbereiten

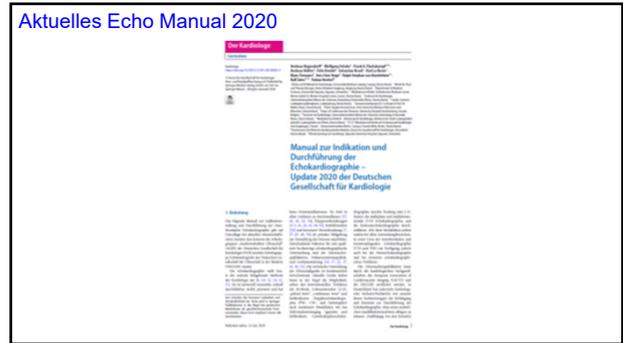
- Klare Fragestellung
- Lagerung (Kopfteil, Kissen, Drainagen, Kabel, Infusionen)
- EKG sichtbar
- Atemkommando
- Links- oder Rechts-Schallen

Jede Methode ist nur so gut wie der Anwender, der sie einsetzt!

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Indikationsbezogene erweiterte Untersuchung

- **Parasternale Schnitte**
 - Linksventrikuläre Masse
 - Rechtskardiale Schnitte
 - RV Hämodynamik
 - Druckgradient über der Pulmonalklappe
 - Trikuspidalklappeninsuffizienz
- **Apikale Schnitte**
 - LV Hämodynamik
 - Diastolische Funktion
 - Pulmonalvenenfluss
 - Systolische Funktion RV (TAPSE, S')
- **Subkostale Schnitte**
 - Vena cava inferior
 - Interatriales Septum
- **Suprasternale Schnitte**

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..kurze Wiederholung: Standard-Schnitte

- Die Standard-Untersuchung beginnt in der Regel mit der **parasternalen Anlotung**
 - PLAX
 - PSAX

Rotating the Probe to the Right Shoulder Rotating the Probe to the Left Shoulder

IVS, RV, AV, LV, MV, LVOT, LA, RA, TV, RVOT, PV, AS, LA

JASE (2019), Volume 32, Issue 1, 1 - 64

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Parasternale lange Achse (PLAX)

PLAX
Anteroseptal und Aorta auf einer Höhe
Posteriore Wand und Perikard sichtbar
Aortenklappenöffnung sichtbar
Mitralklappe sichtbar
Papillarmuskeln nicht sichtbar
Linker Vorhof dargestellt

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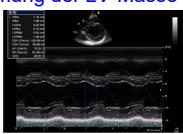
Wo wird gemessen?

Tissue blood interface

Figure 1 Measurement of left ventricular end-diastolic diameter (EDD) and end-systolic diameter (ESD) from M-mode, guided by parasternal short-axis image (upper left) to optimize medial-lateral beam orientation.

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Bestimmung der LV-Masse



Viele Daten, gute Validierung.
Aber:
 Ungenau bei asymmetrischen Ventrikeln
 Messfehler werden verstärkt
 M-Mode Winkel
 Überschätzung der LV-Masse

$$LV_{\text{Mass}} [g] = 0.8 [1.04(LVIDD + IVST + PWT)^3 - LVIDD^3] + 0.6$$

LVIDD: end-diastolischer interner Durchmesser

IVST: ED Septum-Dicke

PWT: ED Hinterwand-Dicke

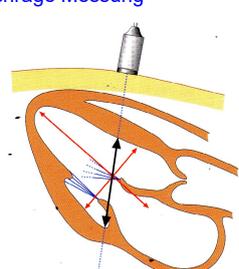
Table 4 Estimates mean and percent values of LV ventricular mass and geometry

Study	Normal		Hypertensive		Hypertensive		Hypertensive	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
LV mass, g	145	35	185	35	205	35	235	35
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10
LV mass/body surface area, g/m ²	45	10	55	10	65	10	75	10

Devereux RB, Am J Cardiol 1986;57:450-8.
 Barbieri A, JASE 2011

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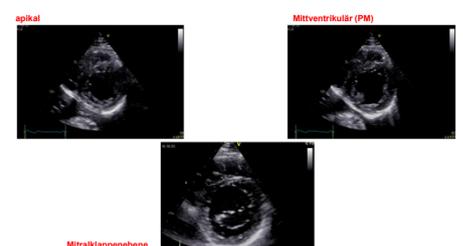
Fehlerquelle: Schräge Messung



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Parasternale kurze Achse (PSAX)

Linker Ventrikel



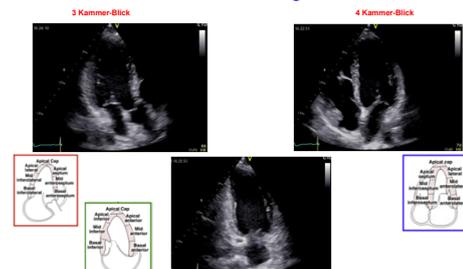
apikal

Mitralklappenebene

Mitventrikulär (PM)

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Apikale Schnitte: Nomenklatur der Segmente



3 Kammer-Blick

4 Kammer-Blick

Apikal view

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APLAX

- Position des Schallkopfs über der Herzspitze
- Mitralklappe mittig
- Aortenklappen-separation
- Sonst keine korrekte Darstellung des Vier- und Zweikammerblicks möglich



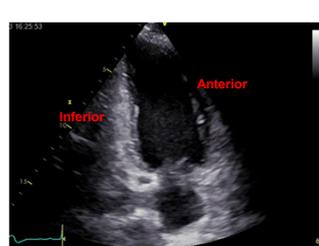
Posterior

Anteroseptal

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Apikaler 2-Kammer-Blick

- 60 Grad-Drehung des Schallkopfes im Uhrzeigersinn
- Marker zeigt zur li Schulter



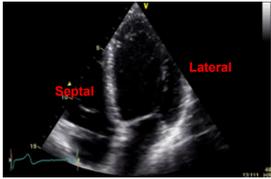
Inferior

Anterior

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Apikaler 4-Kammer-Blick

- Weitere 60°-Drehung des Schallkopfs
- Marker zeigt zur Liege



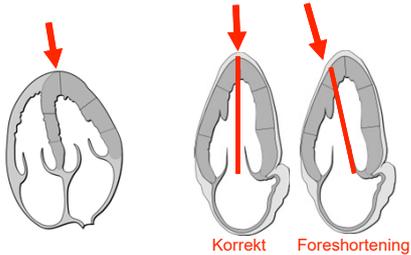
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Schwierigkeit der Anlotung



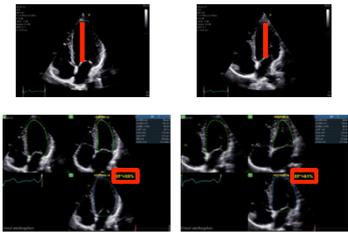
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Schwierigkeit der Anlotung



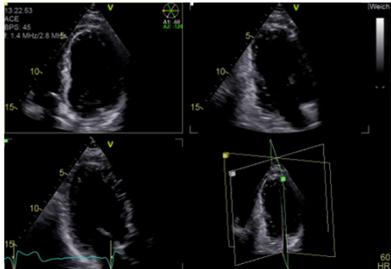
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Schwierigkeit der Anlotung



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Multiplane Aufnahmen

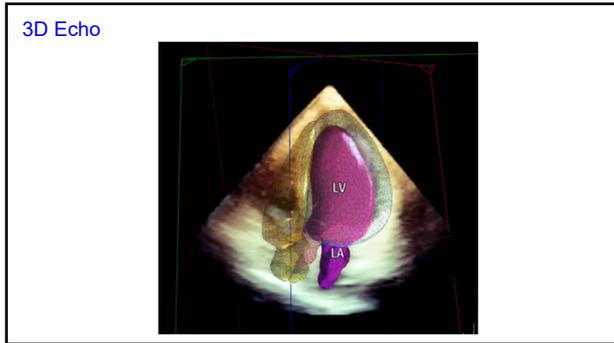


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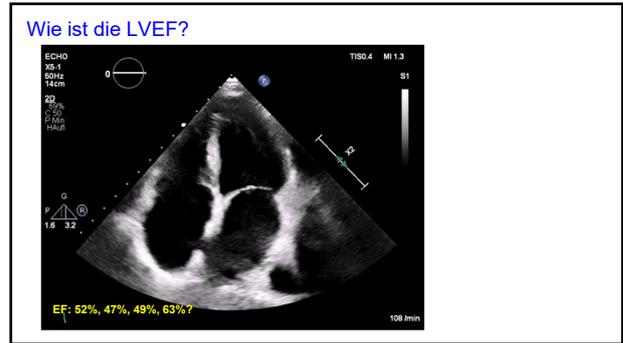
4D LV



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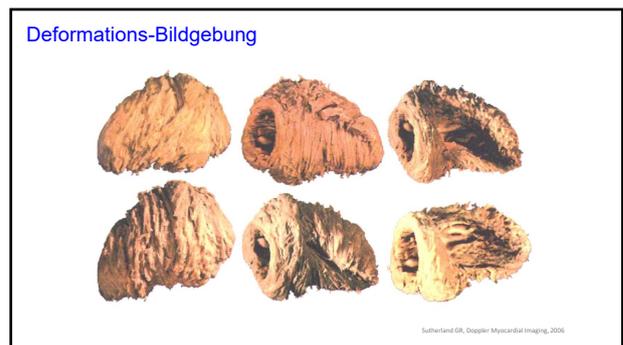
LV Strain

Strain Echocardiography
The New Gold Standard for Imaging Ventricular Function?*

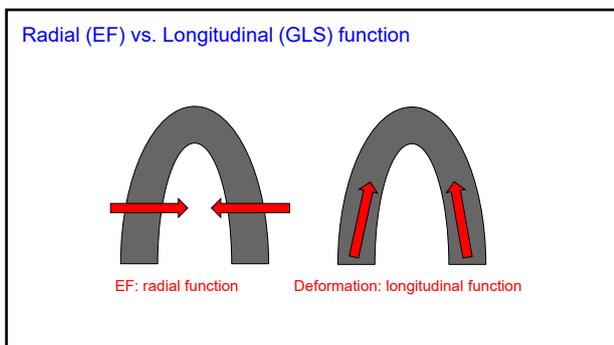
James L. Januzzi, Jr, MD,^{1,2,3,4} Y. Chandrasekhar, MD, DM^{1,2}

JACC 2017

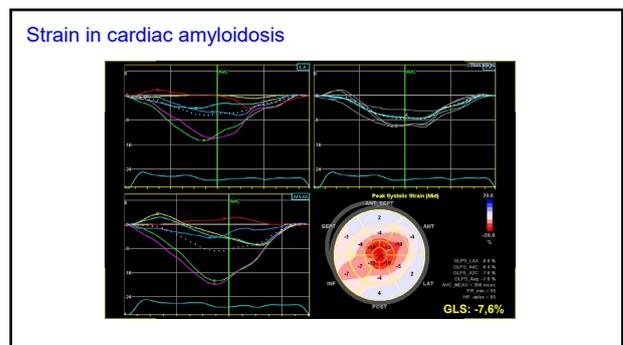
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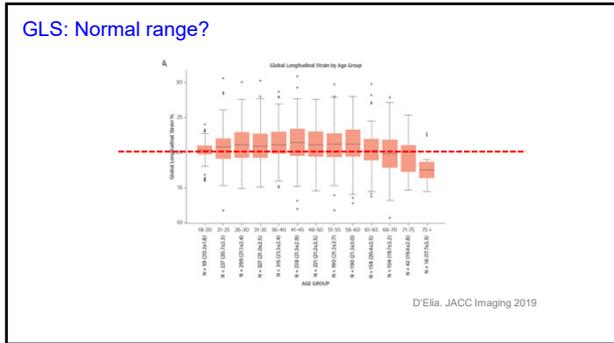
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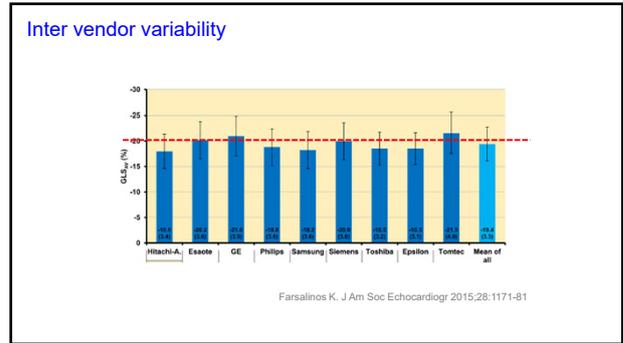
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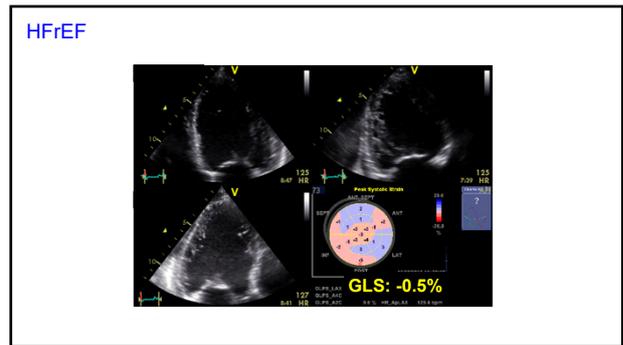
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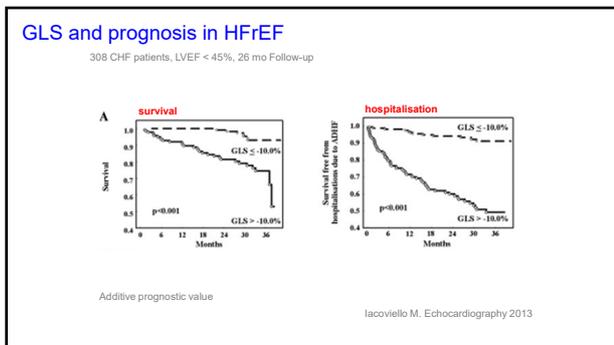
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Risk assessment, prognosis

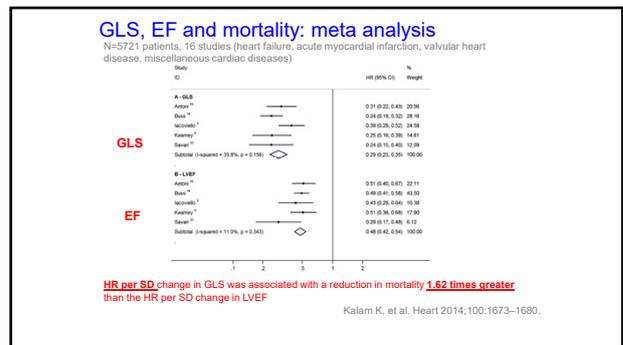
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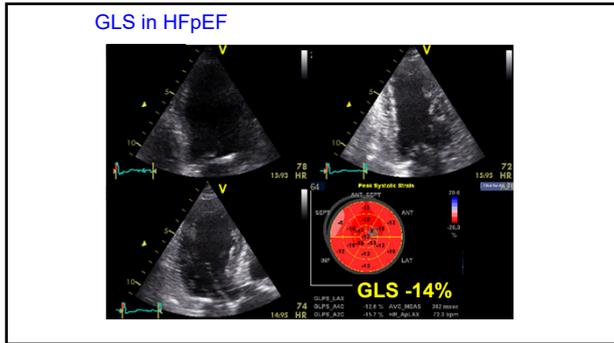
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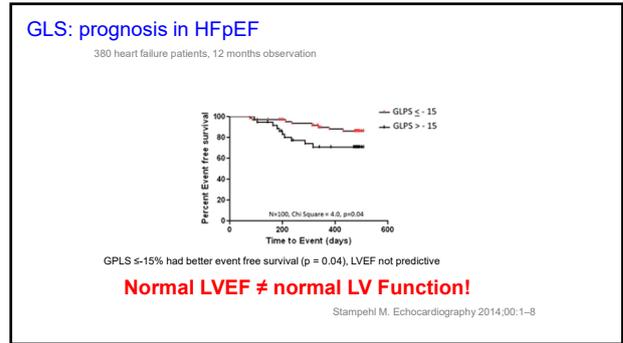
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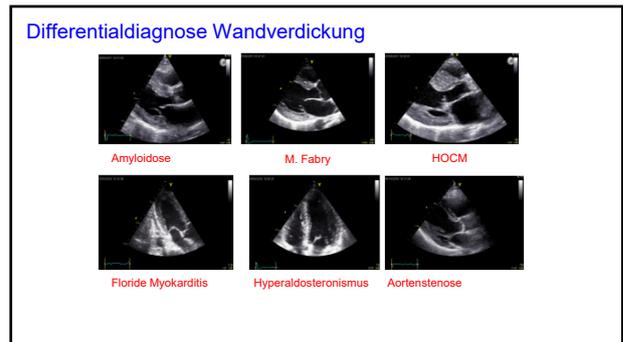
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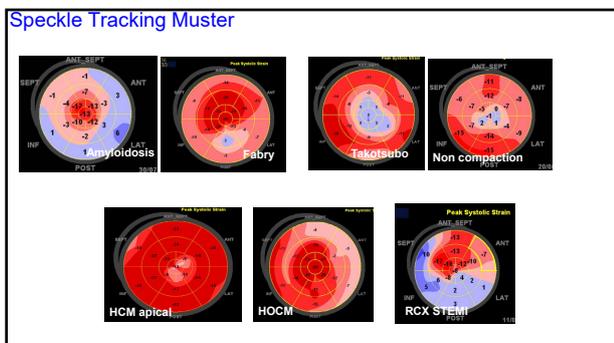
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Diagnosis

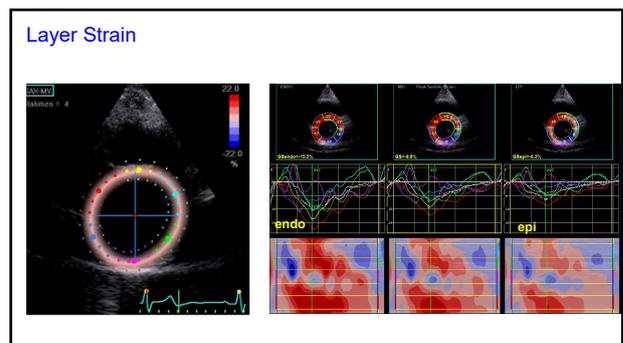
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Follow up

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Optimizing heart failure therapy

Baseline NYHA II-III 12 months of Sac / Val, NYHA I-II

GLS: -8% GLS: -12%

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Eosinophile Kardiomyopathie

GLS: -6% 10 days steroid therapy GLS: -14% GLS: -17%

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Diastolische Funktion

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Diastole? Wichtig?

Man verbringt 2/3 des Lebens in der Diastole*

In der Echokardiografie ist die Diastole oft nur ein untergeordnetes Thema

* Im nSR

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Der linke Vorhof:
Der „Hb-A1c“ der diastolischen Funktion?

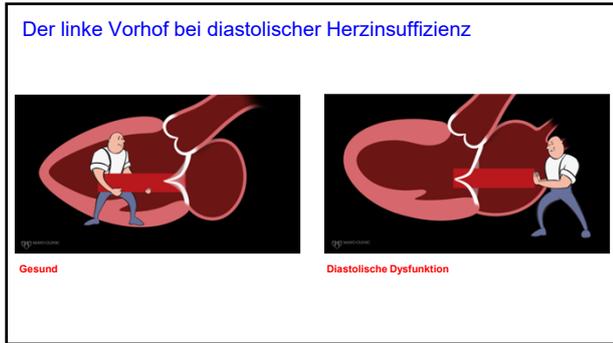
EDITORIAL COMMENT

The Left Atrium

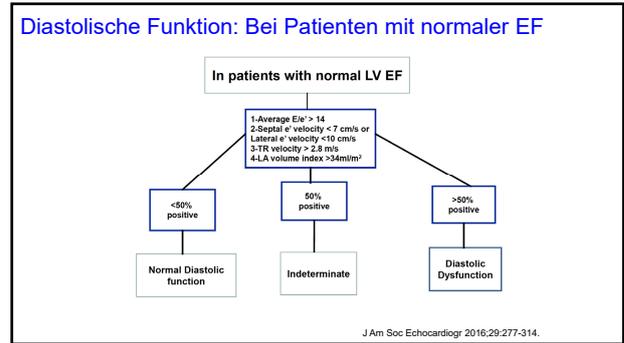
A Biomarker of Chronic Diastolic Dysfunction and Cardiovascular Disease Risk

Douglas P, JACC 2003

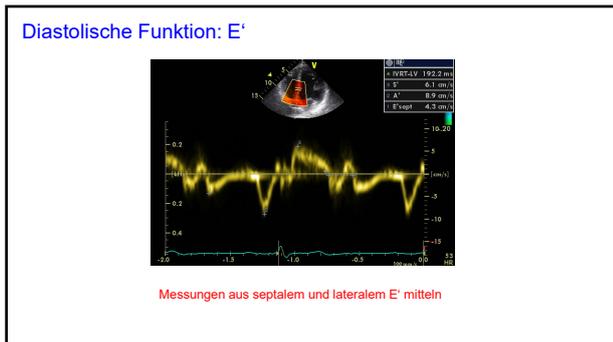
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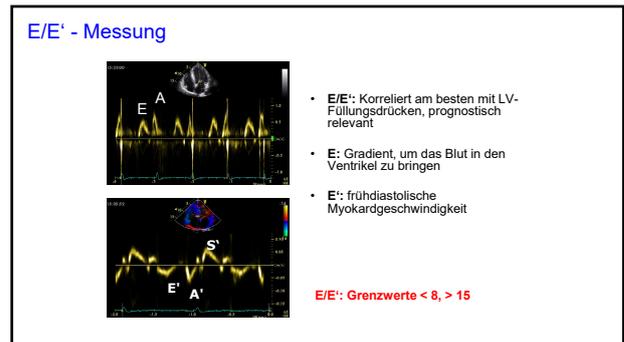
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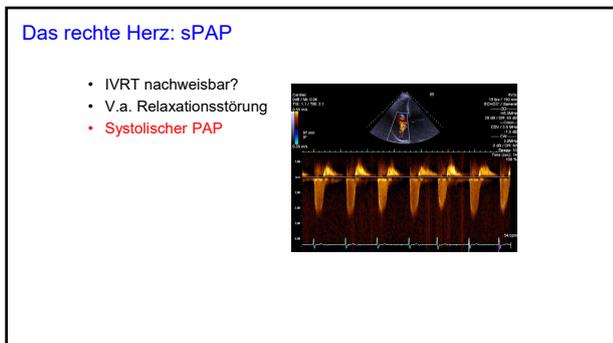
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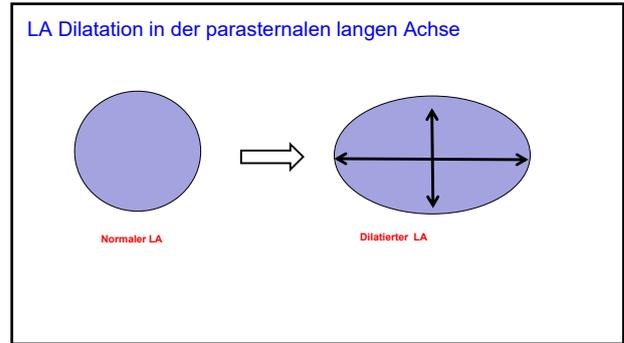
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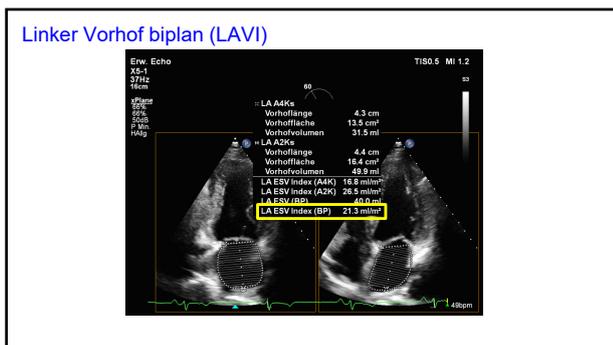
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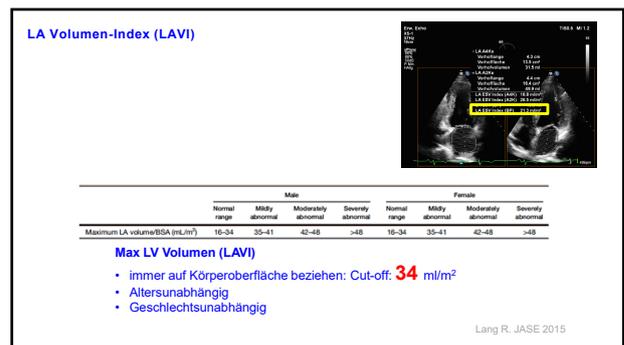
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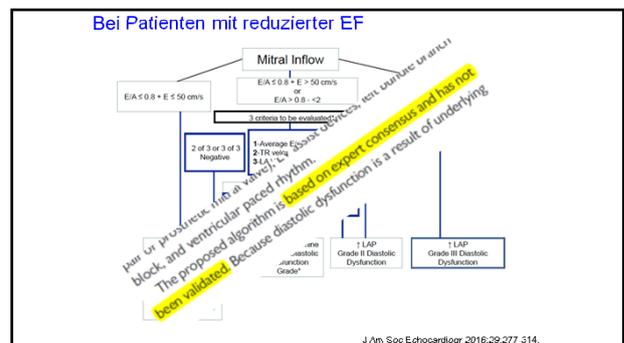
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- ### Die 4 wichtigsten Werte der Guideline
1. **TDI e'** septal (<7 cm/s) und lateral (<10 cm/s)
 2. gemittelteltes **E/e'** >14
 3. „systol. pulmonalarterieller Druck **SPAP**“ > 2,8 m/s (≅ 31 mmHg)
 4. indiziertes Volumen des linken Vorhofs (**LAVI**) >34 ml/m²

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Graduierung der diastolischen Dysfunktion

	Normal	Grad 1	Grad 2	Grad 3
LV Relaxation	Normal	Impaired	Impaired	Impaired
LAP	Normal	Low or normal	Elevated	Elevated
Mitral E/A	≥0.8	≤0.8	> 0.8 to < 2	> 2
Average E/e' ratio	< 10	< 10	10-14	> 14
Peak TR velocity (m/sec)	< 2.8	< 2.8	> 2.8	> 2.8
LA volume index	Normal	Normal or increased	Increased	Increased
		Relaxationsstörung	Pseudonormalisierung	Restriktion

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LA Strain

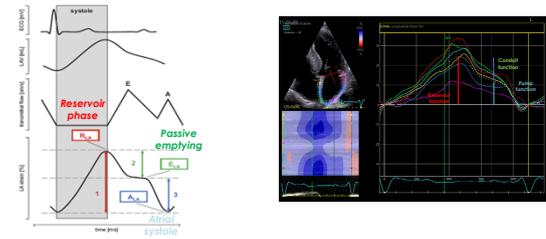
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Der linke Vorhof



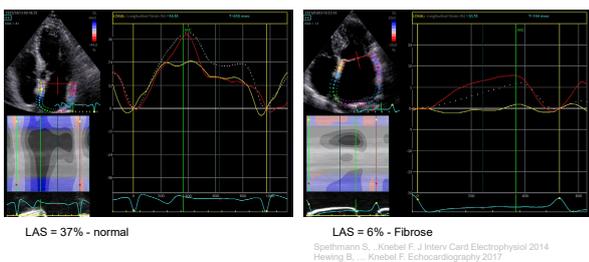
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Physiologie und phasische Funktion des LA



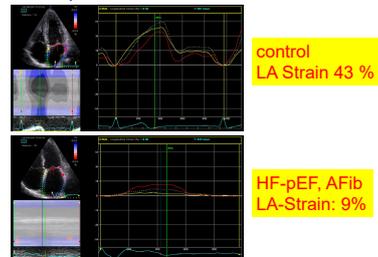
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Echokardiographie des LA – Strain Analyse



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LA strain in HFpEF



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LA Strain: normal values

LA strain component	Number of studies	Mean	95% CI	Cochrane Q	I ²	χ 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	4.20 (P < .001)	96.9	17.9
Contractile	18	17.4	16.0-19.0	6.31 (P < .001)	97.3	9.7

Peak LA Strain ≈ 40%

Pathan JASE 2017

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LA und RV Strain bei Amyloidose

Huntjens PR. JACC 2021

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Strain: Prädiktor bei kardialer Amyloidose

Huntjens PR. JACC 2021

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LA Strain bei Amyloidose und HCM

Brand A, ... Knebel F. Eur Heart J CVI, 2020

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LA Strain bei Amyloidose und HCM

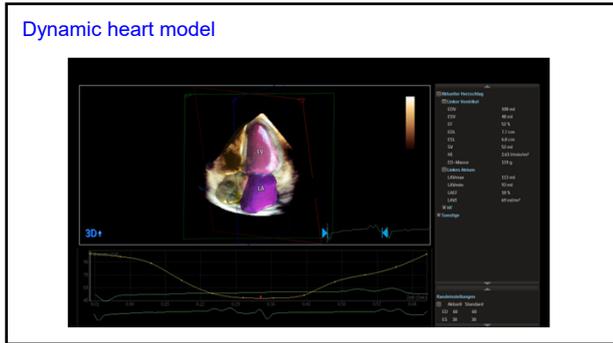
#p = .007; *p < .001

Brand A, ... Knebel F. Eur Heart J CVI 2020

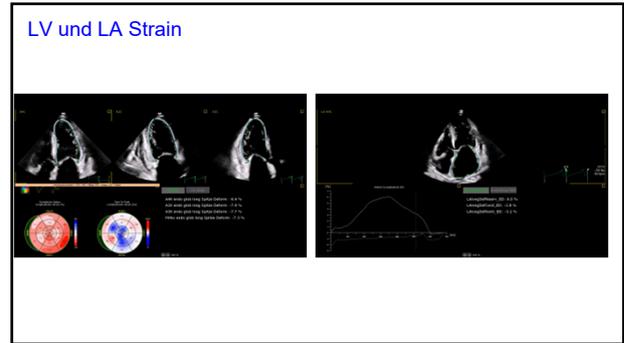
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3D Echo und LA Strain

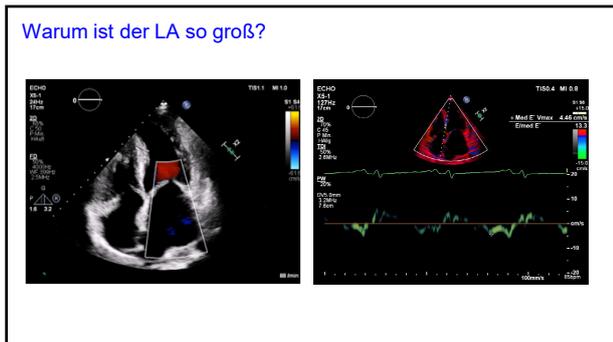
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Der linke Vorhof:
Der „Hb-A1c“ der diastolischen Funktion?

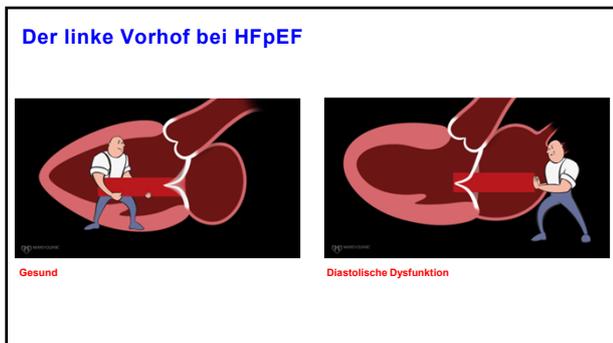
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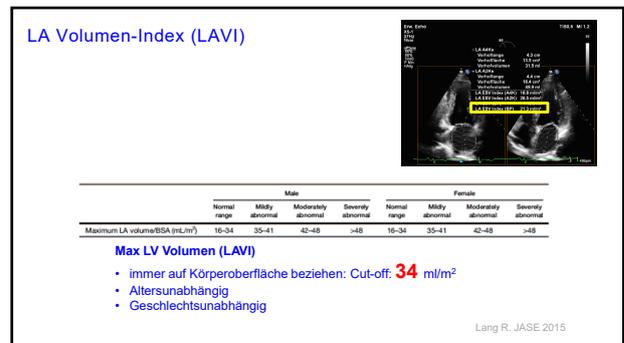
A Biomarker of Chronic Diastolic Dysfunction and Cardiovascular Disease Risk

Douglas P, JACC 2003

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Fallbeispiel: Wie ist die diastolische Funktion?

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Fallbeispiel: multiples Myelom, Dyspnoe NYHA III

Kardiale Amyloidose, NYHA III, NT-proBNP 15.000, GFR 60

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Diastolische Dysfunktion?

1. Av. E/e' > 14 +

2. Medial e' < 7cm/s or lateral e' < 10cm/s +

3. TR velocity > 2.8m/s +

4. LA volume index > 34ml/m² +

<50% positive

50% positive

>50% positive

Normal

Indeterminate

Diastolic Dysfunction

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Non-compaction: Darf man das noch sagen?

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Hypertrabekularisierung vs. Non-compaction

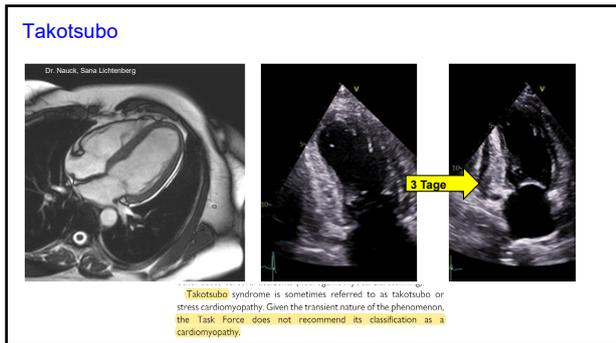
The Task Force does not consider LVNC to be a cardiomyopathy in the general sense. Instead, it is seen as a phenotypic trait that can occur either in isolation or in association with other developmental abnormalities, ventricular hypertrophy, dilatation, and/or systolic dysfunction. Given the lack of morphometric evidence for ventricular compaction in humans,^{21,22} the term "hypertrabeculation", rather than LVNC, is recommended, particularly when the phenomenon is transient or clearly of adult onset.

Arbello E. EHJ 2023

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Takotsubo: Eine Kardiomyopathie?

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