DIAGNOSTICA PER IMMAGINI ED APPROCCI INTERVENTISTICI IN REUMATOLOGIA

Passato, presente e futuro

Ipertensione arteriosa polmonare e interessamento cardiaco nelle connettiviti

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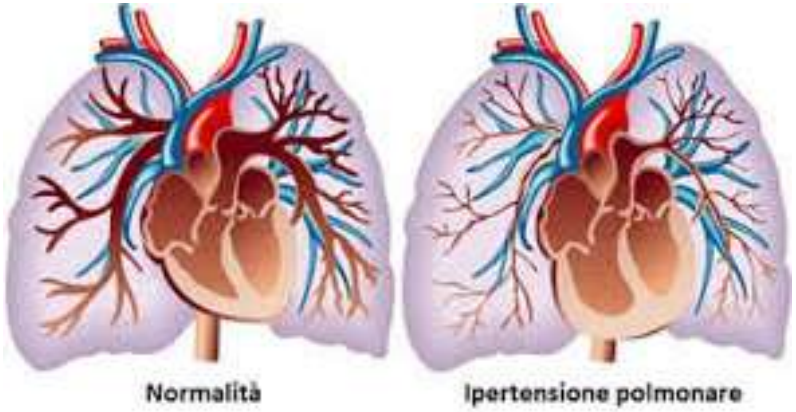
CONNETTIVITI E CUORE



PAH: Definizione

Tabella 1: Definizione emodinamica dell'Ipertensione polmonare valutata con il cateterismo cardiaco destro *		
Definizione	Caratteristiche	Gruppi clinici **
Ipertensione Polmonare (PH)	PAP media ≥ 25 mmHg	Tutti
PH pre-capillare	PAP media ≥ 25 mmHg PWP ≤ 15 mmHg CO normale o ridotta ***	Ipertensione polmonare arteriosa PAH (gruppo1) PH conseguente a malattie polmonari (gruppo3) PH conseguente a malattia tromboembolica cronica (gruppo 4) PH con meccanismi non definiti e/o multifattoriali (gruppo 5)
PH post-capillare	PAP media ≥ 25 mmHg PWP > 15 mmHg CO normale o ridotta ***	PH conseguente a malattie del cuore sinistro (gruppo 2)
Passiva	TPG ≤ 12mmHg	
Reattiva	TPG > 12mmHg	

CO =portata cxardiaca; PAP =pressione arteriposa polmonare; PWP = pressione di incuneamento polmonare; TGP = gradiente pressorio transpolmonare (PAP media-PWP media)

** tutti i valori misurati a riposo*

*** in accordo con la* **Tabella 3**

**** una portata cardiaca elevata può essere presente in condizioni ipercinetiche come anemia, ipertiroidismo...*

ESC Guidelines, European Heart J (2009)

IPERTENSIONE POLMONARE

PAPmedia $\geq$ 25 mmHg a riposo

PH LIEVE : mPAP = 25-35 mmHg

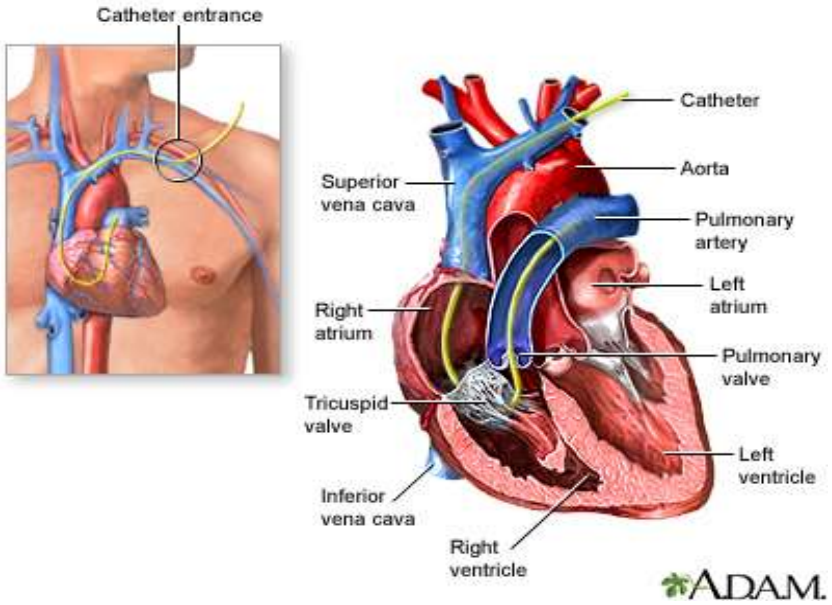
PH MODERATA : mPAP = 36-45 mmHg

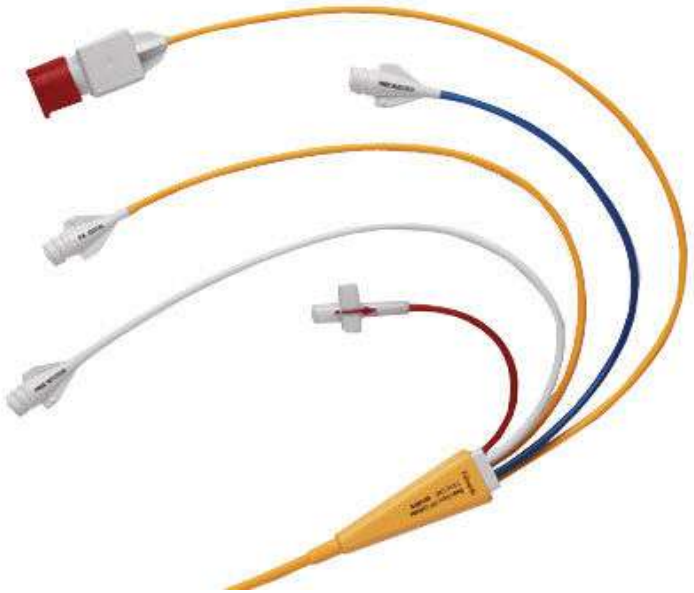
PH SEVERA : mPAP > 45 mmHg

PH postcapillare: PCWP >15 mmHg

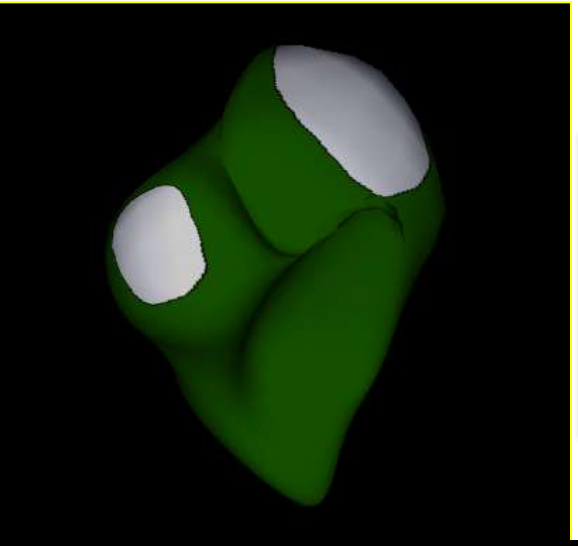
Pulmonary capillary wedge pressure=pressione di incuneamento capillari polmonari


GOLD
STANDARD

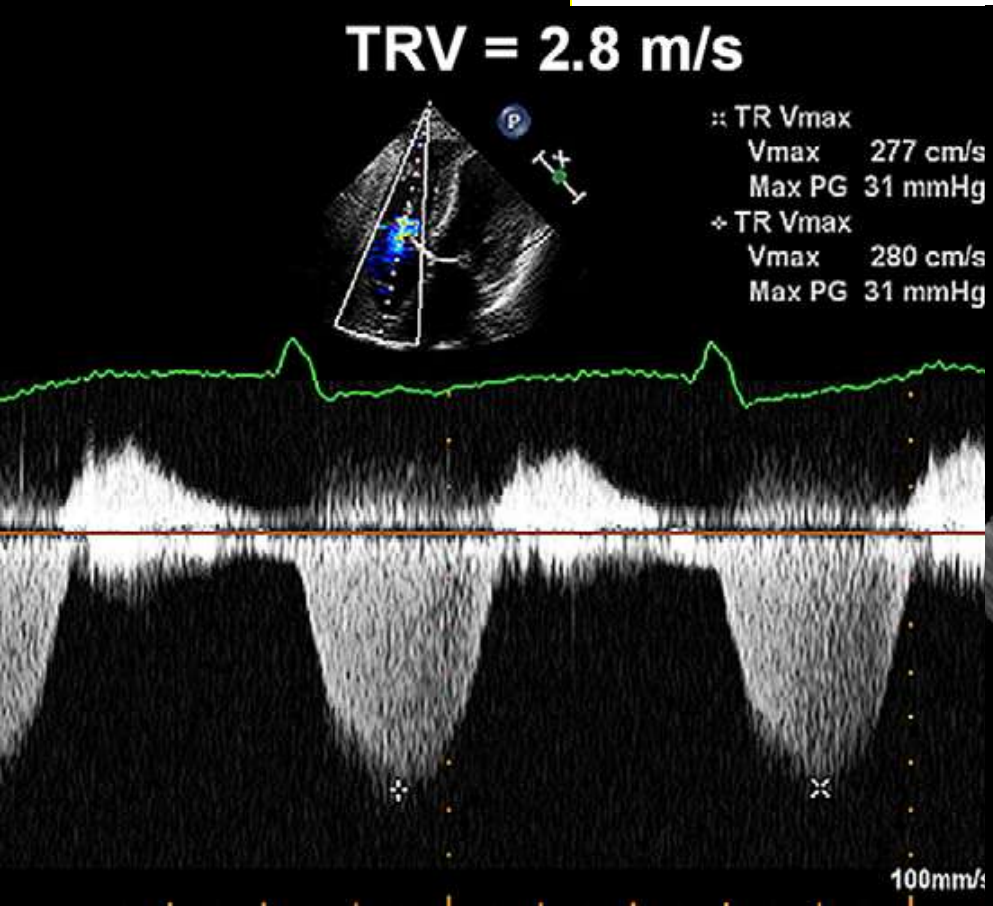

Catheter entrance
Catheter
Aorta
Superior vena cava
Pulmonary artery
Left atrium
Right atrium
Pulmonary valve
Tricuspid valve
Left ventricle
Inferior vena cava
Right ventricle
A.D.A.M.

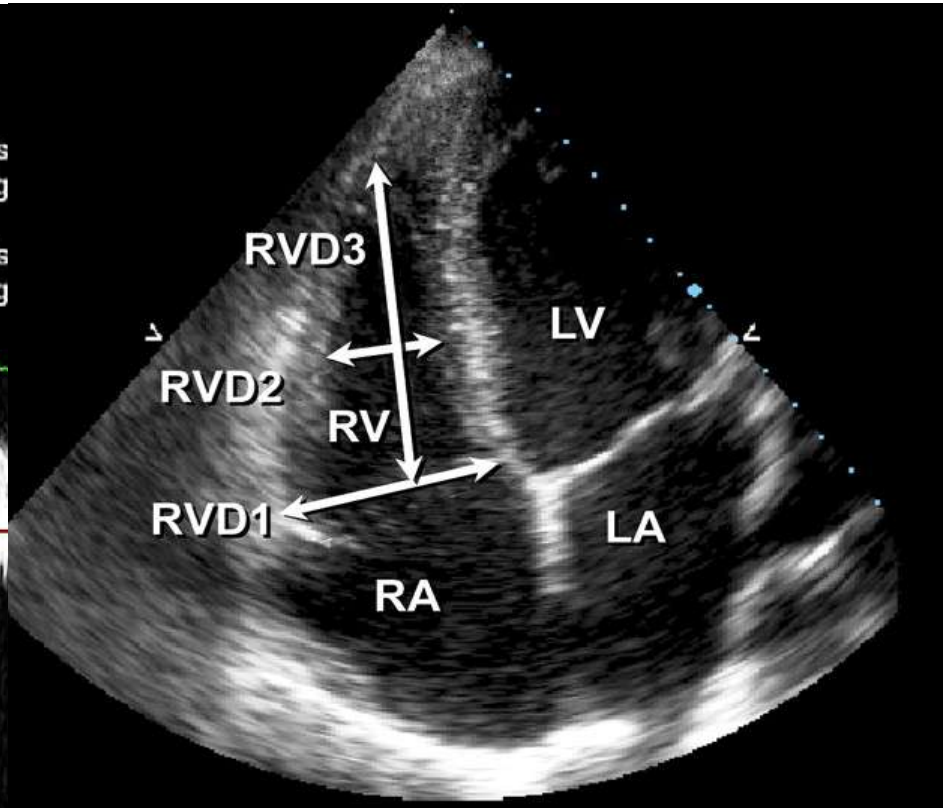


ECOCARDIOGRAFIA



L'ECOCARDIOGRAFIA nello screening di PAH





ECOCARDIOGRAFIA e PAH

- Stima delle pressioni polmonari
- Morfologia delle camere e delle valvole cardiache destre
- Funzione del ventricolo destro
- Ritorno venoso sistemico
- Compressione del ventricolo sinistro
- Versamento pericardico

La stima ecocardiografica della pressione polmonare

GUIDELINES AND STANDARDS

Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography

European Heart Journal (2009) 30, 2493–2537
doi:10.1093/eurheartj/ehp297

Guidelines for the diagnosis and treatment of pulmonary hypertension

Table 9 Arbitrary criteria for estimating the presence of PH based on tricuspid regurgitation peak velocity and Doppler-calculated PA systolic pressure at rest (assuming a normal right atrial pressure of 5 mmHg) and on additional echocardiographic variables suggestive of PH

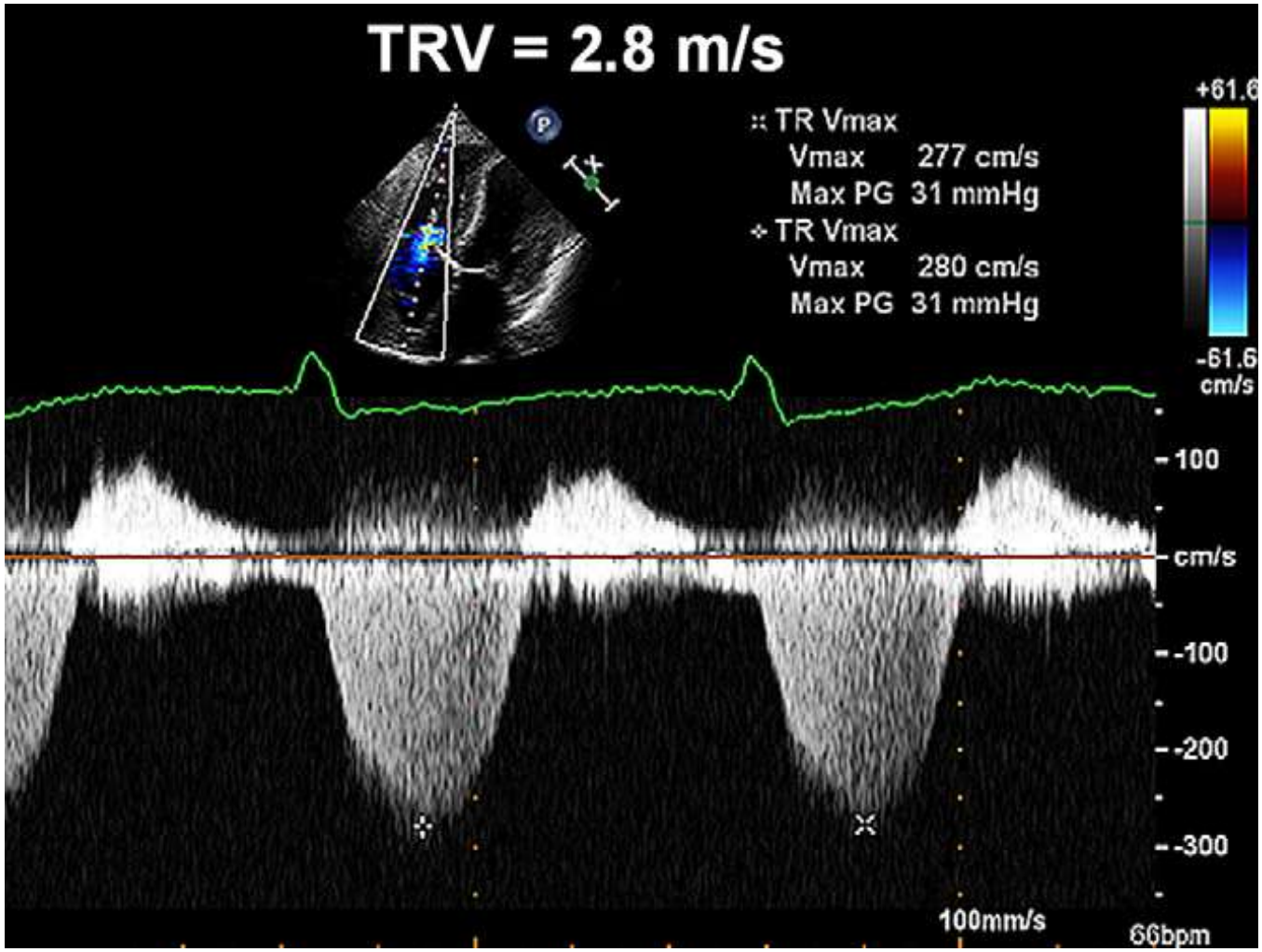
	Class[a]	Level[b]
Echocardiographic diagnosis: PH unlikely		
Tricuspid regurgitation velocity ≤2.8 m/s, PA systolic pressure ≤36 mmHg, and no additional echocardiographic variables suggestive of PH	I	B
Echocardiographic diagnosis: PH possible		
Tricuspid regurgitation velocity ≤2.8 m/s, PA systolic pressure ≤36 mmHg, but presence of additional echocardiographic variables suggestive of PH	IIa	C
Tricuspid regurgitation velocity 2.9–3.4 m/s, PA systolic pressure 37–50 mmHg with/without additional echocardiographic variables suggestive of PH	IIa	C
Echocardiographic diagnosis: PH likely		
Tricuspid regurgitation velocity >3.4 m/s, PA systolic pressure >50 mmHg, with/without additional echocardiographic variables suggestive of PH	I	B
Exercise Doppler echocardiography is not recommended for screening of PH	III	C

[a]Class of recommendation.
[b]Level of evidence.

- **UNLIKELY**: ≤ 2.8 m/s, ≤ 36 mmHg
- **POSSIBLE**: 2.9-3,4 m/s, ma variabili
- **LIKELY**: 3.4 m/s, > 50 mmHg

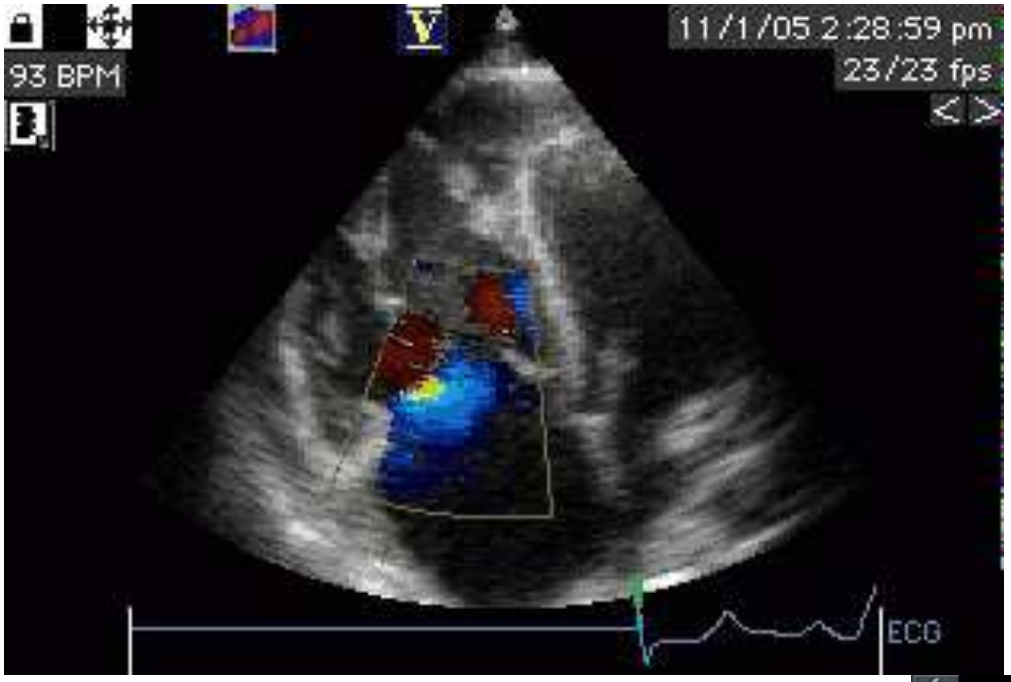
PAPs

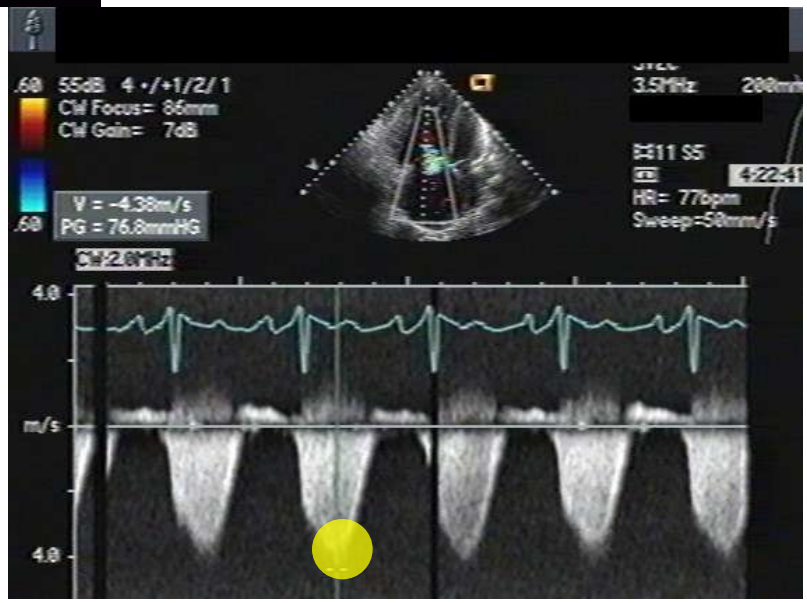
$$PAPs = 4V^2_{TricRig} + PAD$$



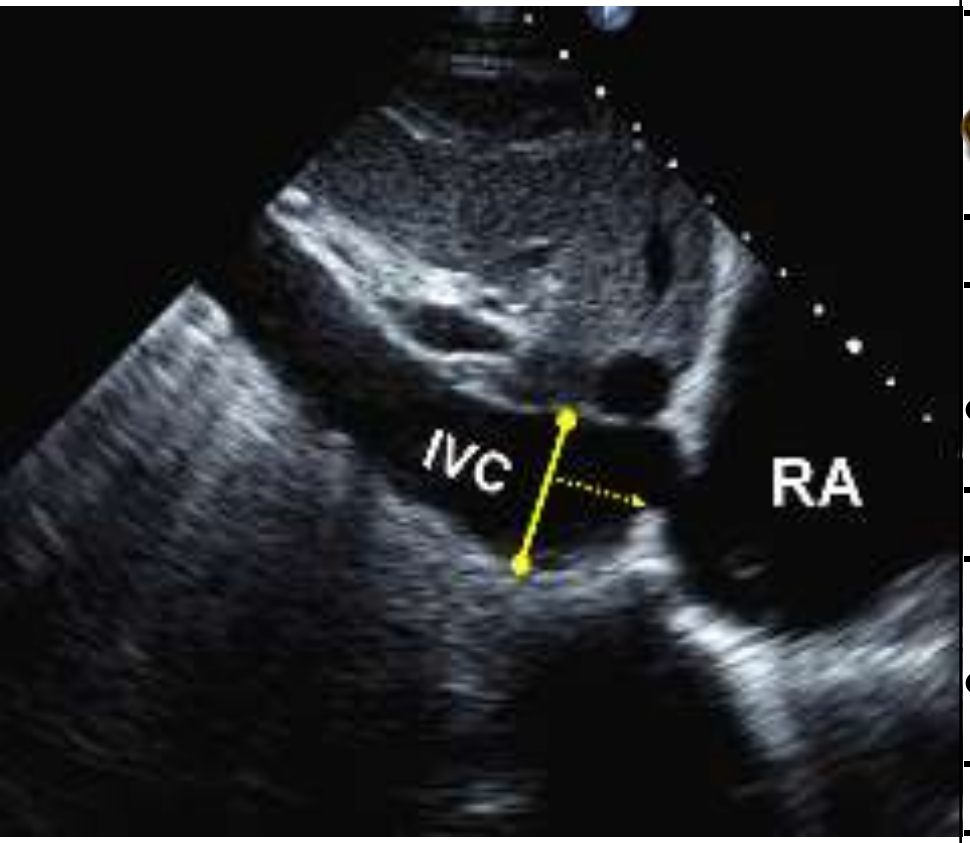
Relazione tra gradiente pressorio tra VDx e ADx e Vmax del jet di rigurgito della IT

Rudski LG; J Am Soc Echocardiogr. 2010 Jul;23(7):685-713; quiz 786-8
Yock PG; Circulation. 1984 Oct;70(4):657-62.


11/1/05 2:28:59 pm
23/23 fps
93 BPM
ECG


55dB
CW Focus= 86mm
CW Gain= 7dB
V = -4.38m/s
PG = 76.8mmHG
CW2.0MHz
3.5MHz
HR= 77bpm
Sweep=50mm/s
4.0
m/s
4.0

STIMA PRESSIONE ADX - IVC



- Fine espirazione
- Perpendicolare asse lungo IVC
- 0.5 - 3 cm dall'ostio

- Normale (0-5 mmHg):
- diam ≤ 21 mm
- collasso > 50%

- Alta (15 mmHg):
- diam > 21 mm
- collasso < 50%

- Inoltre, alta RAP se:
- pattern diast restrittivo
- E/E'tric > 6
- flusso diast dominante vv sovraepatiche)

La stima ecocardiografica della pressione polmonare: LIMITI

PAPs = 4TRV^2 + PAD

- ***Stima*, non misurazione come cath**
- ***Non sempre possibile*: assenza o esiguità IT**
- ***Sottostima* se IT severa o non corretto allineamento**
- ***Pressione sistolica in VDx = PAPs solo se non vi è stenosi/ostruzione a livello di RVOT, valvola polmonare o arteria polmonare o sue diramazioni (attenzione a cardiopatie congenite!)***

La stima ecocardiografica della pressione polmonare

Buona metodica di screening:

- Non invasiva
- Semplice
- Poco costosa
- Facilmente applicabile
- Sensibilità?
- Specificità?

Diagnostic accuracy of echocardiography for pulmonary hypertension: a systematic review and meta-analysis

Surinder Janda, Neal Shahidi, Kenneth Gin, John Swiston

Results 29 studies were included in the meta-analysis. The summary correlation coefficient between systolic pulmonary arterial pressure estimated from echocardiography versus measured by right heart catheterisation was 0.70 (95% CI 0.67 to 0.73; n=27). The summary sensitivity and specificity for echocardiography for diagnosing pulmonary hypertension was 83% (95% CI 73 to 90) and 72% (95% CI 53 to 85; n=12), respectively. The summary diagnostic OR was 13 (95% CI 5 to 31).

Sensibilità: 83%

Specificità: 72%

Heart 2011;**97**:612–622. doi:10.1136/hrt.2010.212084

The Diagnostic Accuracy of Doppler Echocardiography in Assessment of Pulmonary Artery Systolic Pressure: A Meta-Analysis

Mohammed Taleb, M.D. Sadik Khuder, Ph.D. Jodi Tinkel, M.D., and Samer J. Khouri, M.D.

University of Toledo, Toledo, Ohio

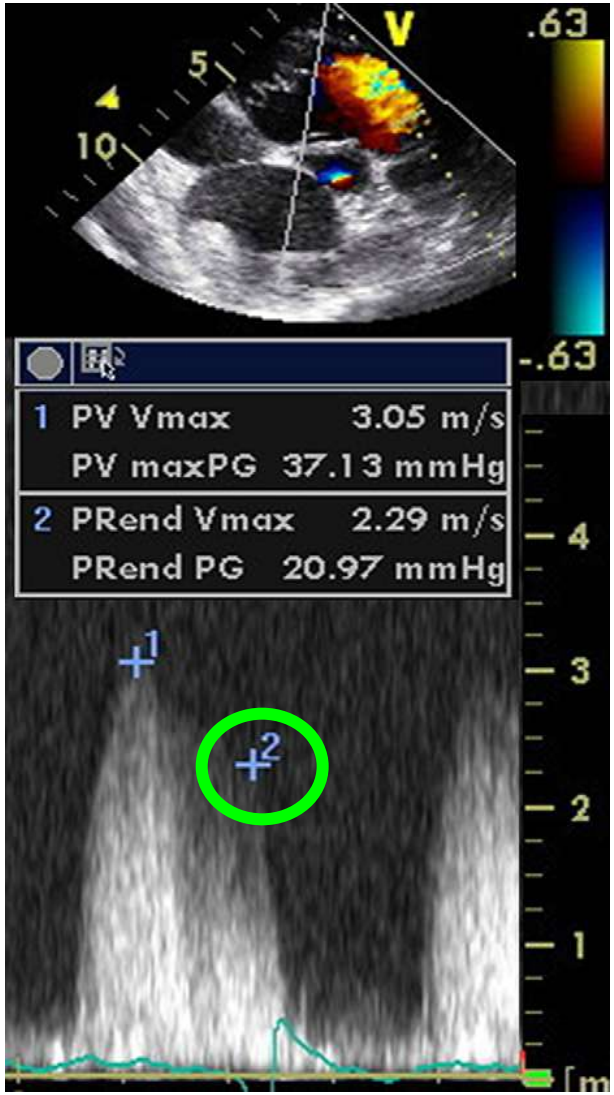
Background: Transthoracic echocardiography is commonly used to estimate pulmonary arterial systolic pressure (PASP) and to diagnose pulmonary hypertension (PH). However, some recent studies have questioned the accuracy of Doppler echocardiography (DE) in the assessment of PASP. The present meta-analysis was performed to estimate the accuracy, sensitivity, and specificity of DE in the assessment of PASP. Methods: A literature search and data extraction of English and non-English articles reported from May 1984 to January 2009 was performed independently by 2 investigators using MEDLINE and EMBASE databases. Articles were included if they compared DE with right heart catheterization (RHC) in the assessment of PASP. Nine articles met our criteria and were included in our meta-analysis. We conducted a meta-analysis of the results of these articles using fixed- and random-effect models to estimate the accuracy, sensitivity, and specificity of DE in the assessment of PASP. Results: The correlation between PASP estimated by DE and RHC ranged from ($r = 0.65$, $P < 0.001$) to ($r = 0.97$, $P < 0.001$). The pooled sensitivity, specificity, and accuracy of DE for the diagnosis of PH were 88% (95% confidence interval [CI], 84–92%), 56% (95% CI, 46–66%), and 63% (95% CI, 53–73%), respectively. Conclusion: DE is a useful noninvasive modality to screen for PH and can reliably determine whether PASP is normal, mildly elevated, or markedly elevated. However, abnormal results from DE need to be confirmed by RHC. (Echocardiography 2012;0:1-8)

Sensibilità: 88%

Specificità: 56%

Echocardiography, 2012 Dec 10. doi: 10.1111/echo.12061. [Epub ahead of print]

Se PAPs non misurabile?



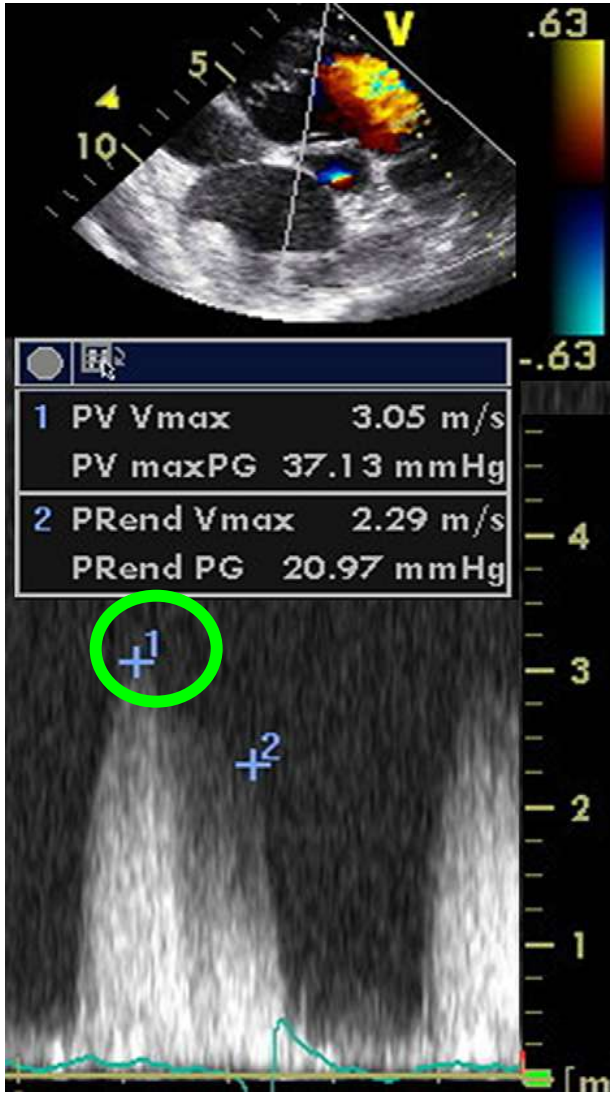
PAP DIASTOLICA

PAPd ≅

4 (end-diastolic pulmonary regurgitant Velocity)^2 + PAD

Rudski LG; J Am Soc Echocardiogr. 2010 Jul;23(7):685-713

Se PAPs non misurabile?



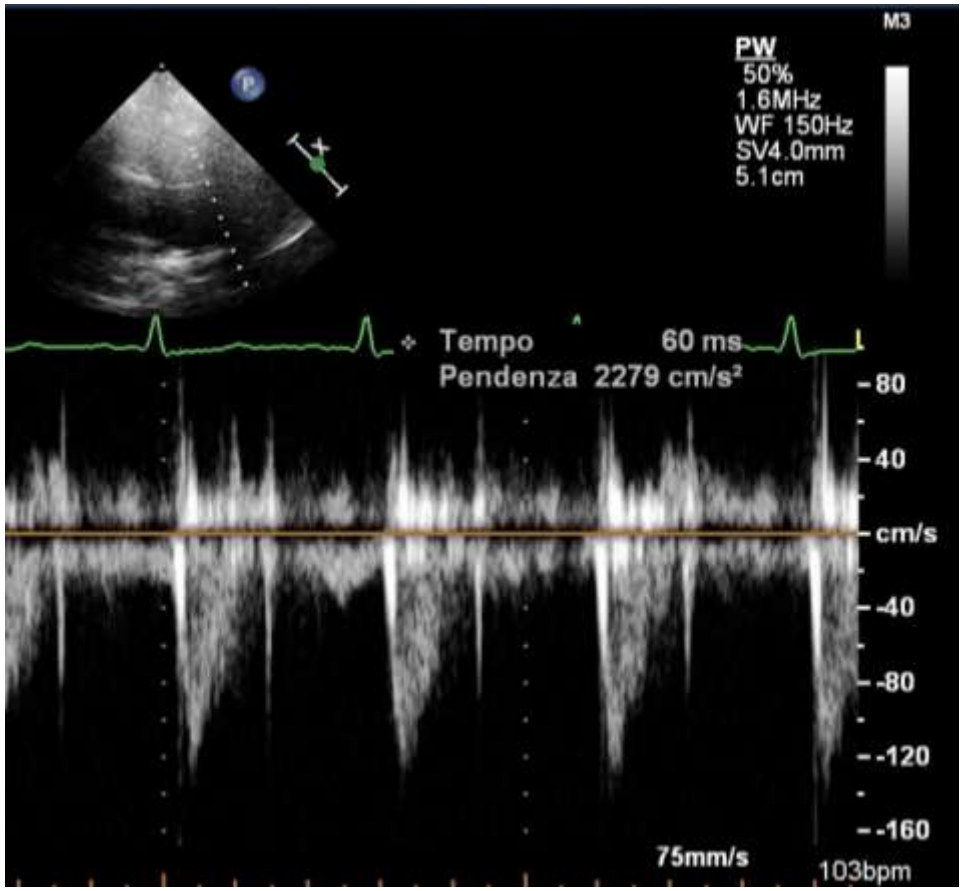
PAP MEDIA

PAPm =

4 (early pulmonary regurgitant Velocity)² + PAD

Rudski LG; J Am Soc Echocardiogr. 2010 Jul;23(7):685-713

Se PAPs non misurabile?



Tempo accelerazione polmonare (ACT)

Inversamente proporzionale a PAPs e PAPm (v.n. > 120 ms)

PAPm =

$$79 - (0{,}45 \times AT)^2$$

o

Se AT<120

$$90 - (0{,}62 \times AT)^2$$

Valido se FC = 60-90 /min

Huez S et al; Eur Respir J 2007; 30 (5): 928-36
*Serra et al; Cardiovascular Ultrasound 2010, **8:25***

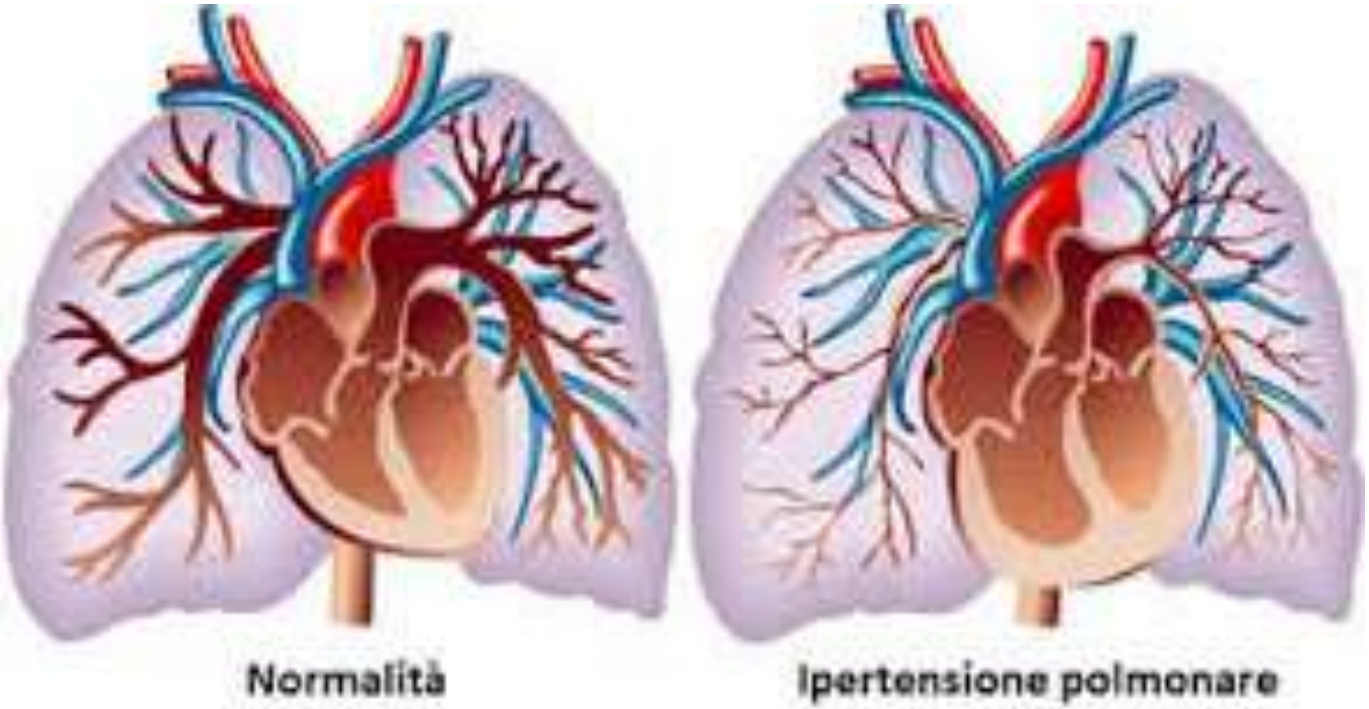
La stima ecocardiografica della pressione polmonare

CONCLUSIONI

- Cath: gold st[illegible]ard
- EchoDopple[illegible]ima metodica d[illegible]reening…

NON FA DIAGNOSI DI HP

CONNETTIVITI E CUORE



Echo Doppler Predictors of Pulmonary Artery Hypertension in Patients with Systemic Sclerosis

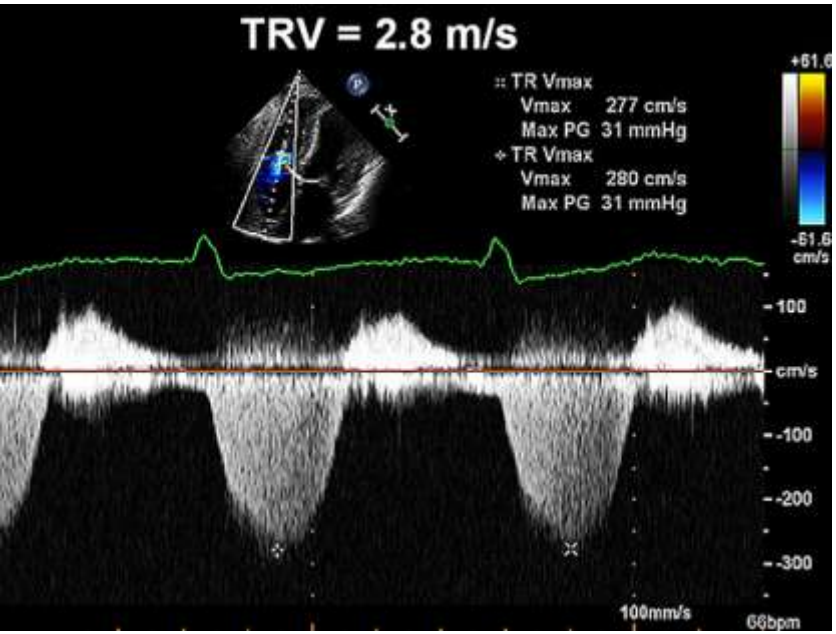
Simone Frea, M.D.,* Michele Capriolo, M.D.,* Walter Grosso Marra, M.D.,* Margherita Cannillo, M.D.,* Enrico Fusaro, M.D.,† Daniela Libertucci, M.D.,‡ Mara Morello, M.D.,* and Fiorenzo Gaita, M.D.*

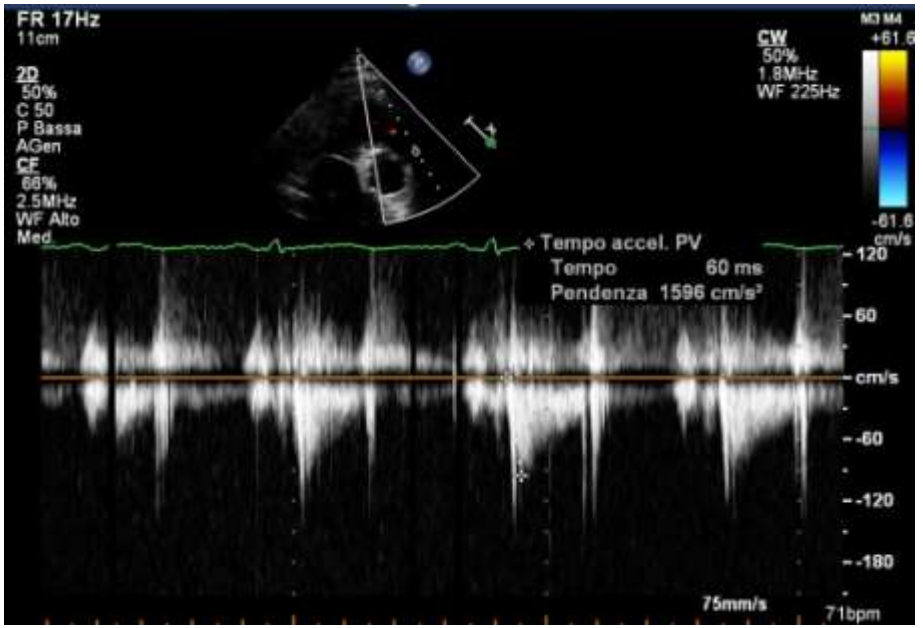
Objectives: Evaluate echocardiographic predictors of pulmonary artery hypertension (PAH) in a prospective cohort of patients with systemic sclerosis (SSc). Methods: 38 patients with SSc who did not have PAH and significant left heart disease, with peak tricuspid regurgitant velocity (TRV) $\leq$ 2.8 m/sec and systolic pulmonary artery pressure (sPAP) $<$ 40 mmHg on echo Doppler were enrolled. Patients underwent: clinical assessment, NT-proBNP, and DLco measurements. Echo Doppler evaluation included right ventricular (RV) dimensions, tricuspid annular plan systolic excursion, fractional area change, tricuspid DTI systolic velocity, Tei index, pulmonary flow acceleration time (AcT), ratio of TRV to RV outflow tract time–velocity integral (TVI) and a parameter of disturbed RV ejection (TRV/AcT). After a planned 12-month follow-up we evaluated the predictive value of these parameters for the development of PAH, as demonstrated by right heart catheterization (RHC). Criteria for RHC were TRV $\geq$ 3 m/sec or sPAP $\geq$ 40 mmHg. Results: Four patients developed PAH. Only TRV/TVI and TRV/AcT ratios significantly predicted PAH development (TRV/TVI ratio $\geq$ 0.16 [predefined and ROC confirmed]: OR 99, CI 95%: 4.865–2015, P = 0.004; TRV/AcT ratio $\geq$ 0.022 [predefined and ROC confirmed]: OR 12.68, CI 95% 1.163–379.3, P = 0.036). Both parameters showed a good diagnostic power (TRV/TVI ratio: ROC area 79%, sensitivity 75%, specificity 97% and diagnostic accuracy 94.74% for cutoff value of 0.16; TRV/AcT ratio: ROC area 75%, sensitivity 75%, specificity 71% and diagnostic accuracy 72% for cutoff value of 0.022). Conclusions: This prospective study identified increased values of the two ratios TRV/TVI and TRV/AcT as predictors of PAH in SSc. (Echocardiography 2011;28: 860-869)

Key words: pulmonary artery hypertension, systemic sclerosis, right ventricular function, Tei index, tissue Doppler echocardiography

Echocardiography 2011; 28: 860-869

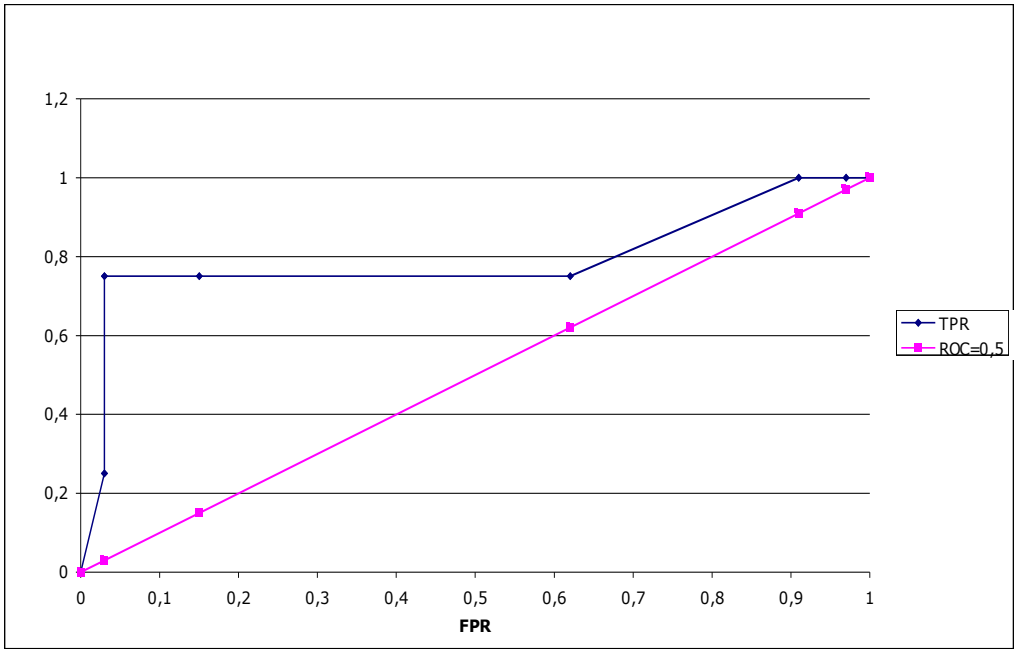
Parametro di disturbata eiezione ventricolare dx: TRV/AcT pulm





TRV/AcT pulm ≥ 0.022
predittore di sviluppo di PAH

Echocardiography 2011; 28: 860-869



TRV/TVI rvot

ROC area: 79 %

TRV/TVI > 0.16:

Sensitivity: 75%

Specificity 97%

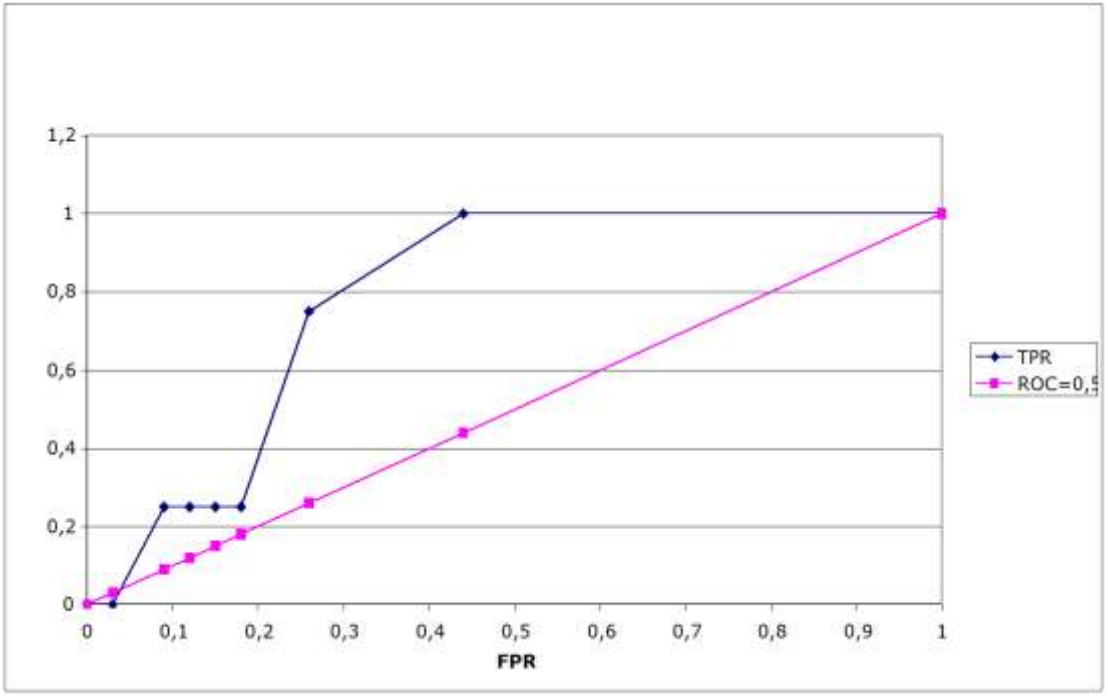
TRV/AcT polm

ROC area: 75%

TRV/AcP ≥ 0.022

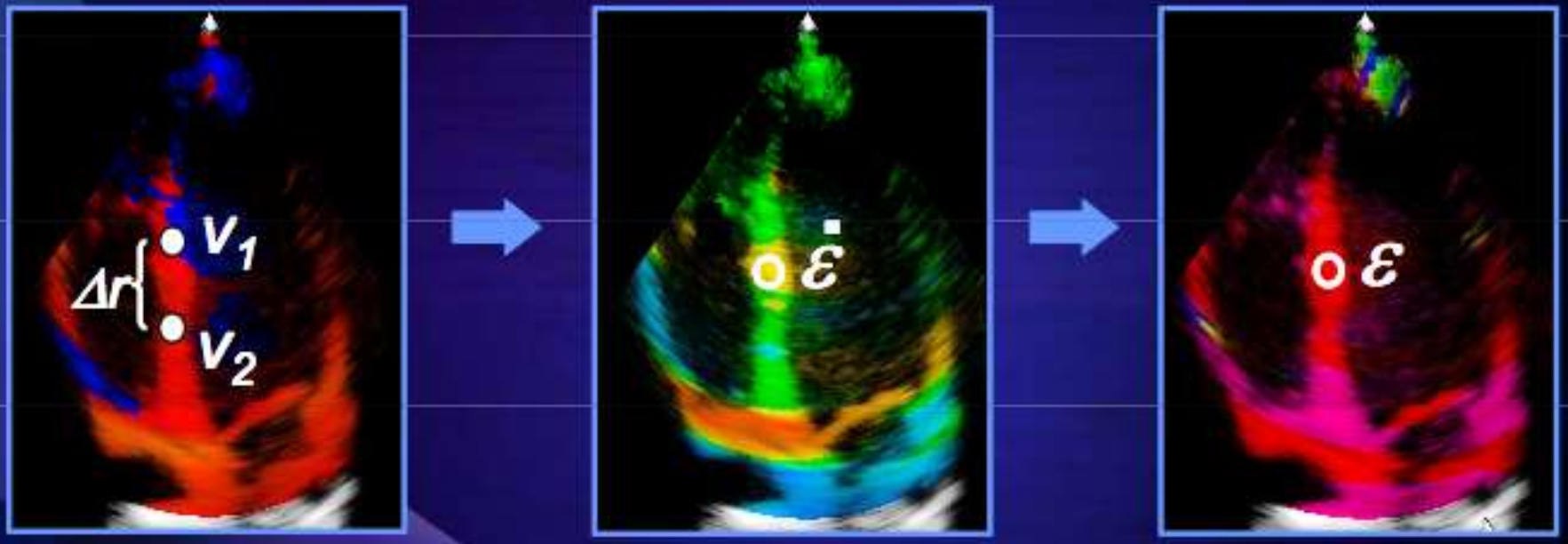
Sensitivity 75%

Specificity 71%



Strain Rate Imaging

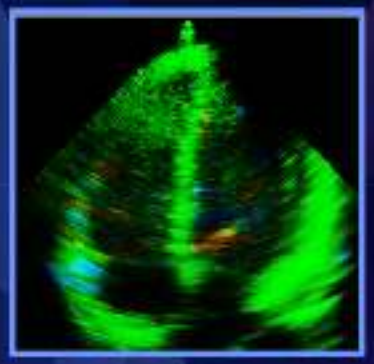
Velocities → **Natural Strain Rate** → **Natural Strain**



Calculate spatial gradient

Integrate temporally

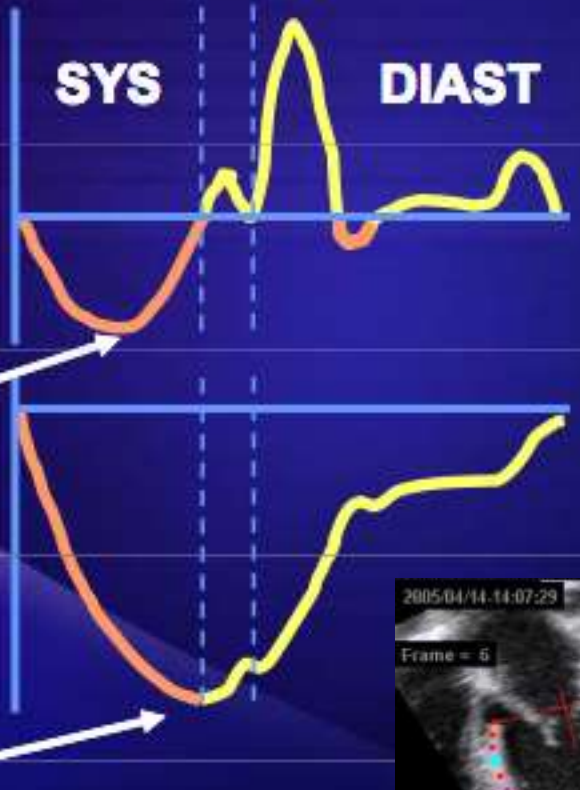
Strain (rate) estimation = velocity estimation + post processing

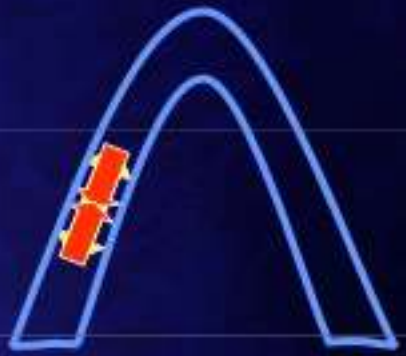


Strain Rate Imaging
Longitudinal Function

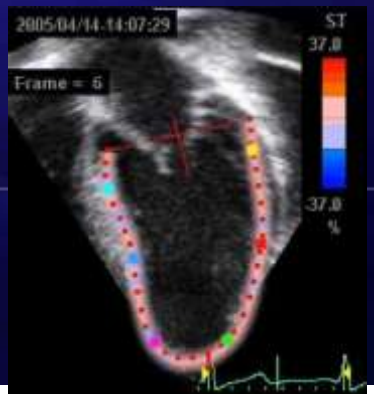
Shortening

Lengthening





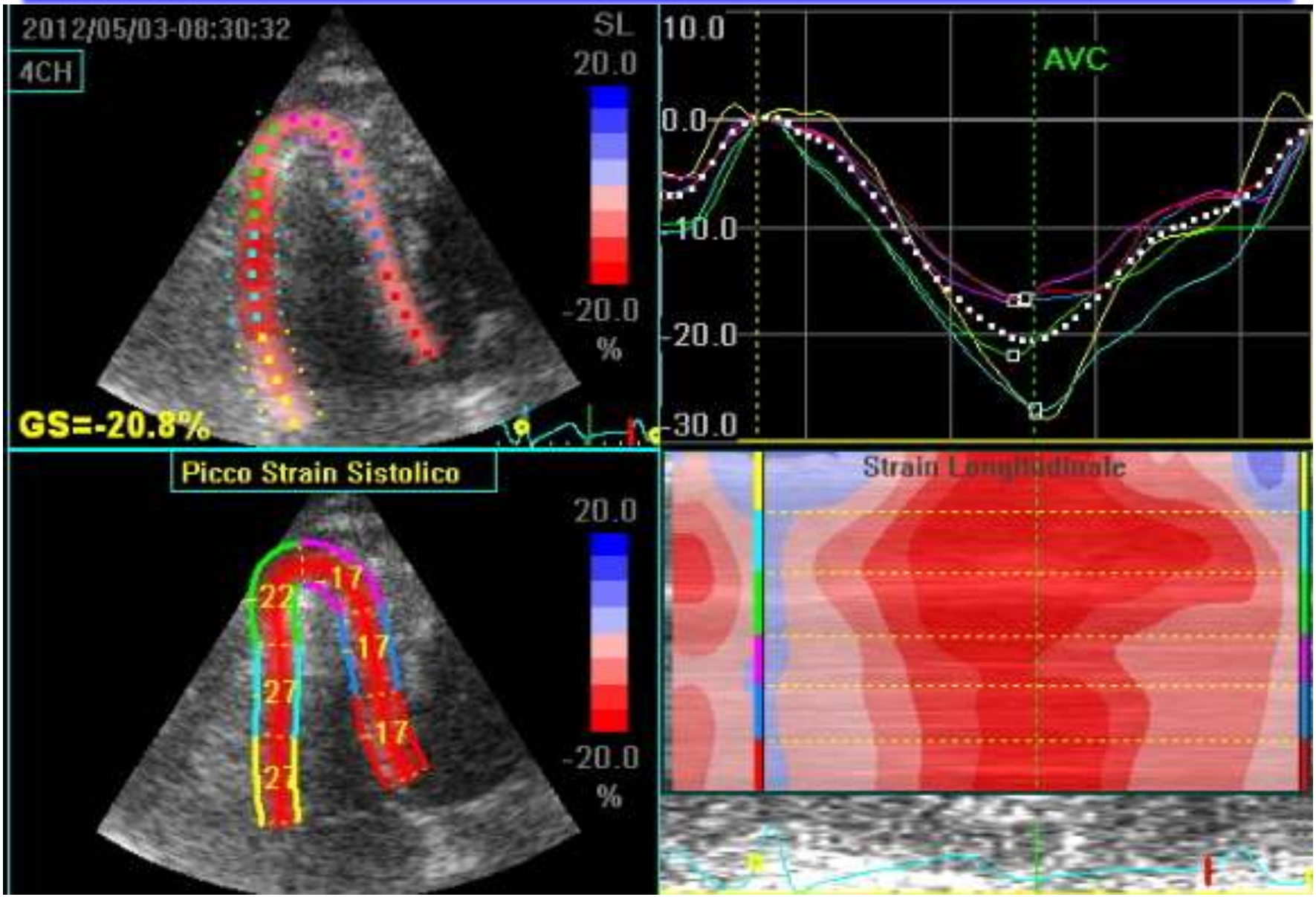
Strain rate (sec^{-1})



Strain (%)

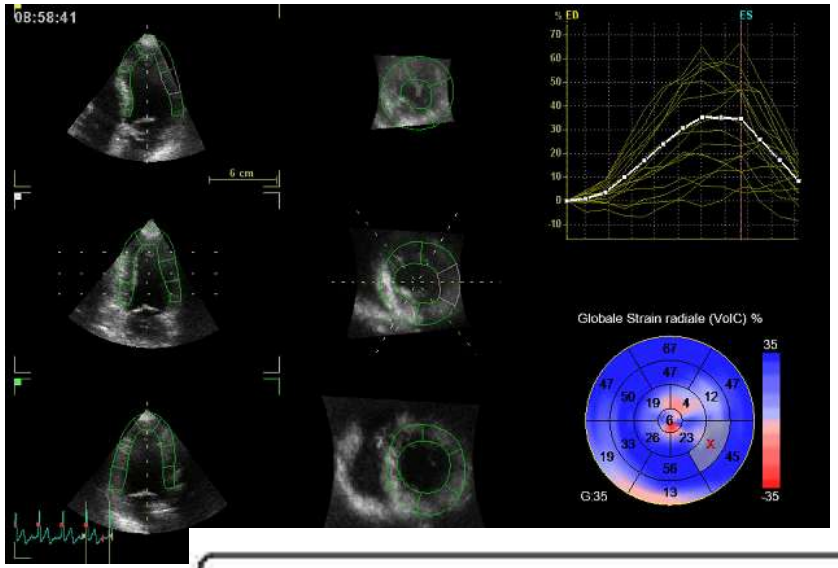
MAYO CLINIC

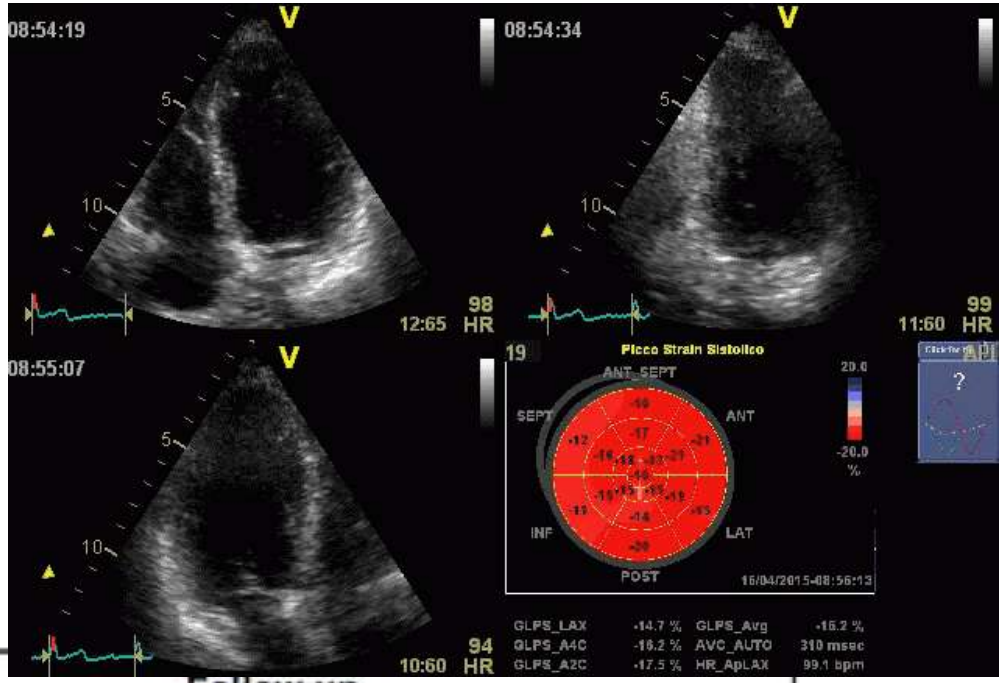
2D-STRAIN VENTRICOLO DESTRO



3D E 3D STRAIN

3D E 3D STRAIN





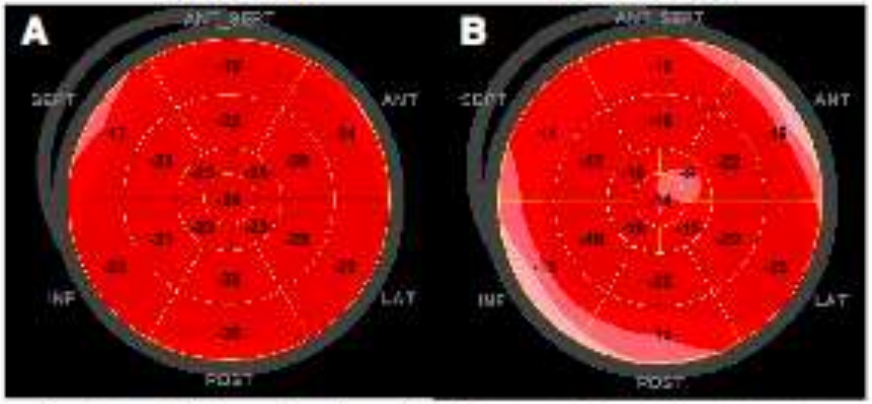


Figure 4 Bull's-eye diagram of a patient with SSc at baseline and at follow-up. Left Panel (**A**): a global longitudinal peak systolic strain of -21.6% at baseline. Right Panel (**B**): a global longitudinal peak systolic strain of -16.1% at follow-up (Right Panel, **B**).

Echocardiographic follow-up of patients with systemic sclerosis by 2D speckle tracking echocardiography of the left ventricle

Sebastian Spethmann[1,2*], Karl Rieper[1], Gabriela Riemekasten[3,4], Adrian C Borges[5], Sebastian Schattke[5], Gerd-Ruediger Burmester[3], Bernd Hewing[1], Gert Baumann[1], Henryk Dreger[1] and Fabian Knebel[1]

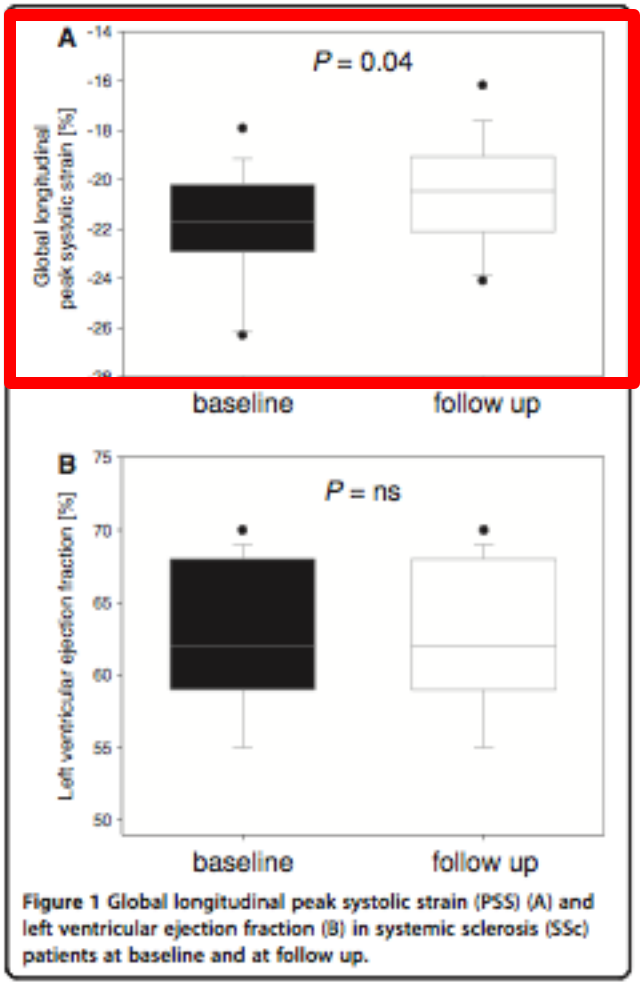


Figure 1 Global longitudinal peak systolic strain (PSS) (A) and left ventricular ejection fraction (B) in systemic sclerosis (SSc) patients at baseline and at follow up.

Table 2 Conventional echocardiographic data

	Baseline (n = 19)	Follow-up (n = 19)	*p*-value
Heart rate, (bmp)	71.2 ± 11.5	69.7 ± 8.8	ns
LVEDV, (ml)	62.9 ± 21.4	71.8 ± 28.5	ns
LVESV, (ml)	23.5 ± 9.3	27.0 ± 13.7	ns
LV mass index, (g/m^2)	89.2 ± 14.3	93.8 ± 19.5	ns
Aortic valve peak instantaneous velocity, (m/s)	1.3 ± 0.2	1.4 ± 0.3	ns
LV diastolic function			
E, (m/s)	0.70 ± 0.16	0.70 ± 0.15	ns
A, (m/s)	0.69 ± 0.14	0.74 ± 0.14	ns
E/A	1.0 ± 0.3	1.0 ± 0.2	ns
E', (cm/s)	8.5 ± 2.1	8.4 ± 2.3	ns
A', (cm/s)	9.3 ± 1.9	9.4 ± 2.1	ns
E/E'	8.4 ± 2.0	8.8 ± 2.8	ns
DT, (ms)	183.1 ± 50.8	176.9 ± 37.6	ns

Data are expressed as mean ± SD. LVEDV, left ventricular enddiastolic volume; LVESV, left ventricular endsystolic volume; LV left ventricular; DT, deceleration time.

Spethmann et al. Cardiovascular Ultrasound 2014, 12:13


F. Netter M.D.
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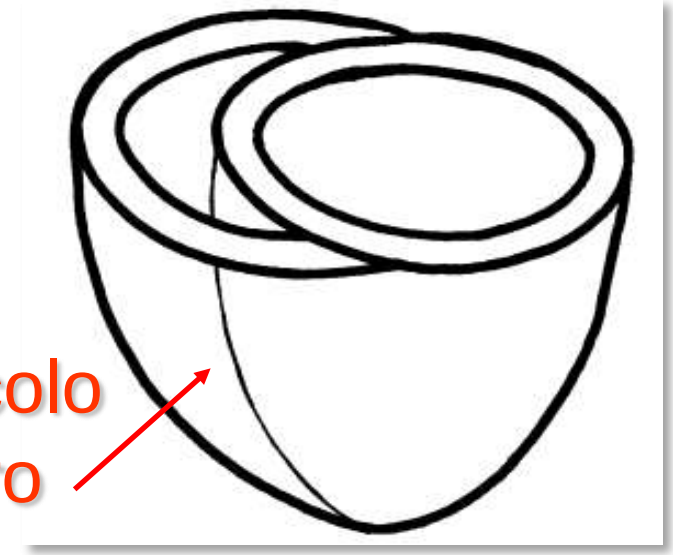
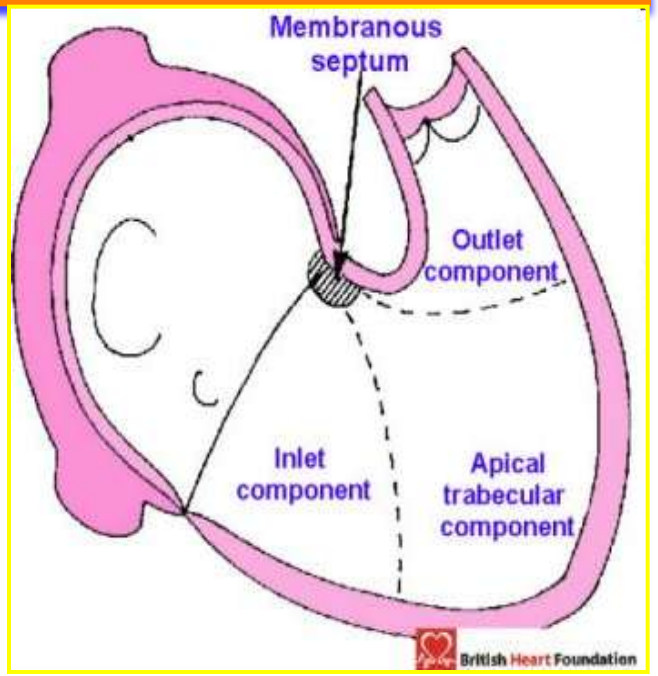
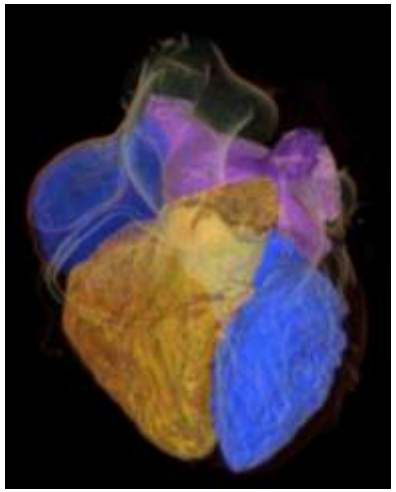
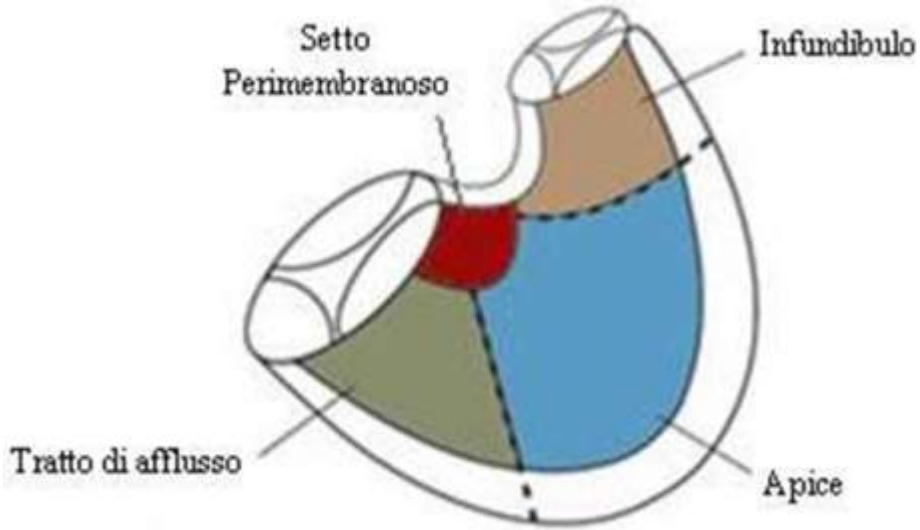
RIGHT ATRIUM OPENED AND VIEWED FROM THE RIGHT SID
PERICARDIAL REFLECTION
AORTA
TRANSVERSE PERICARDIAL SINUS
SUPERIOR VENA CAVA
PULMONARY TRUNK
TRANSVERSE PERICARDIAL SINUS
ANTERIOR CUSP
RIGHT CUSP
LEFT CUSP
PULMONIC VALVE
LA VALUTAZIONE DEL VENTRICOLO DESTRO
TRI-CUSPID VALVE
MEDIAL (SEPTAL) CUSP
POSTERIOR CUSP
MODERATOR BAND
POSTERIOR PAPILLARY MUSCLE
ANTERIOR PAPILLARY MUSCLE
TRABECULAE CARNEAE
RIGHT VENTRICLE OPENED AND VIEWED FROM IN FRONT

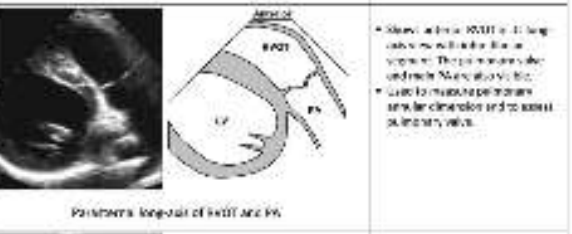
VENTRICOLO DESTRO

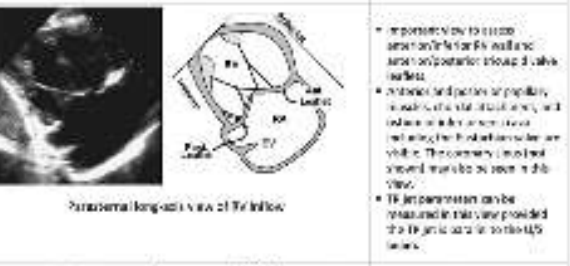


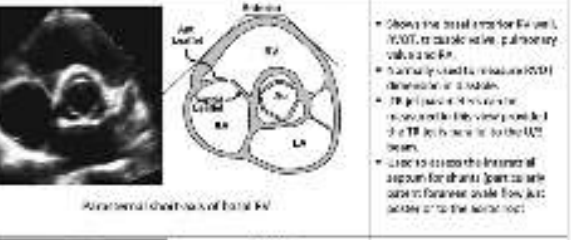


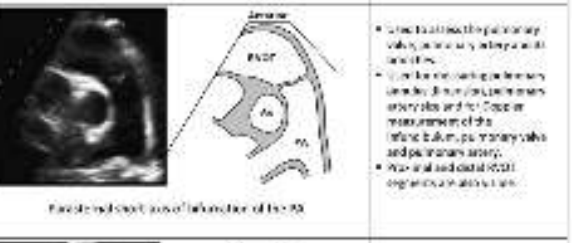


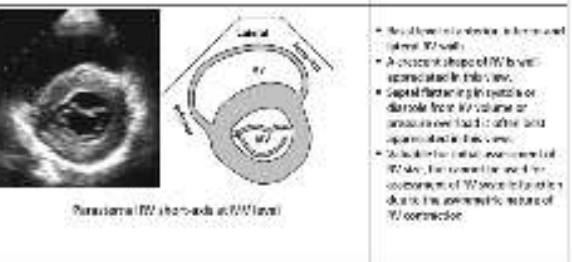


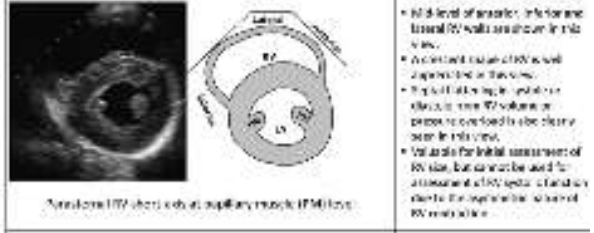


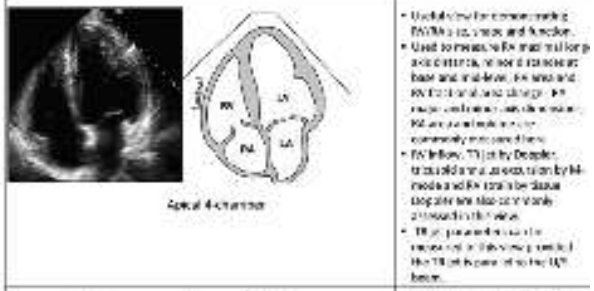


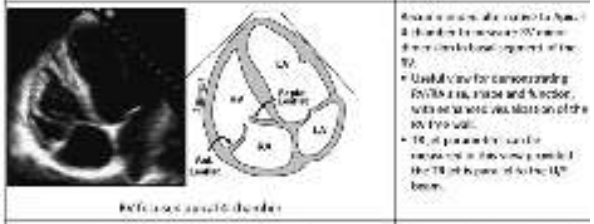


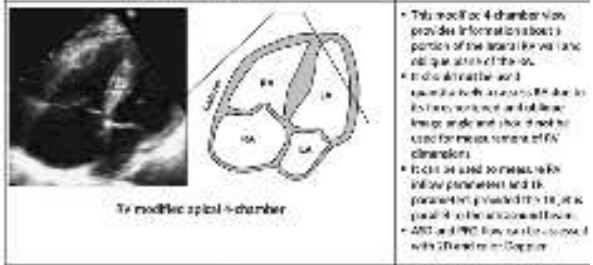


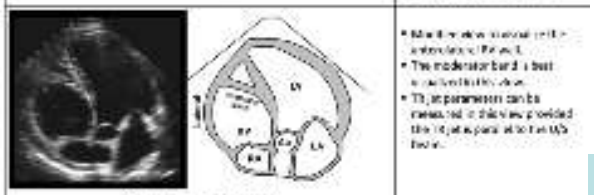


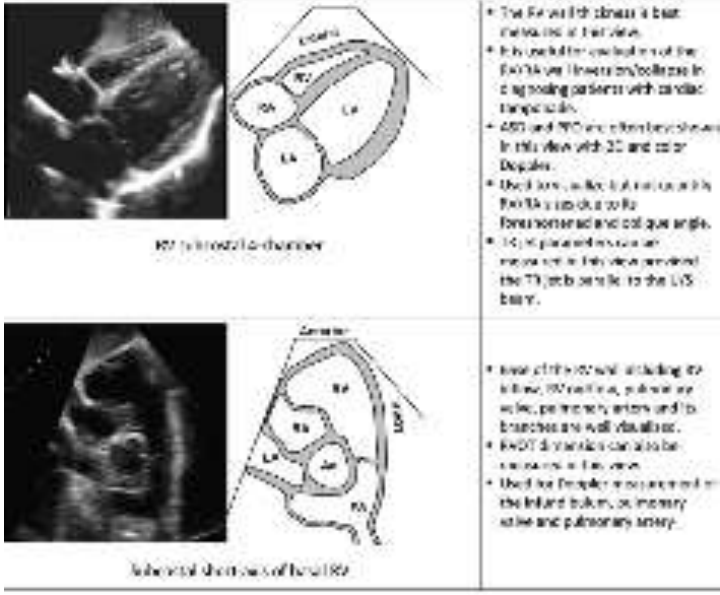










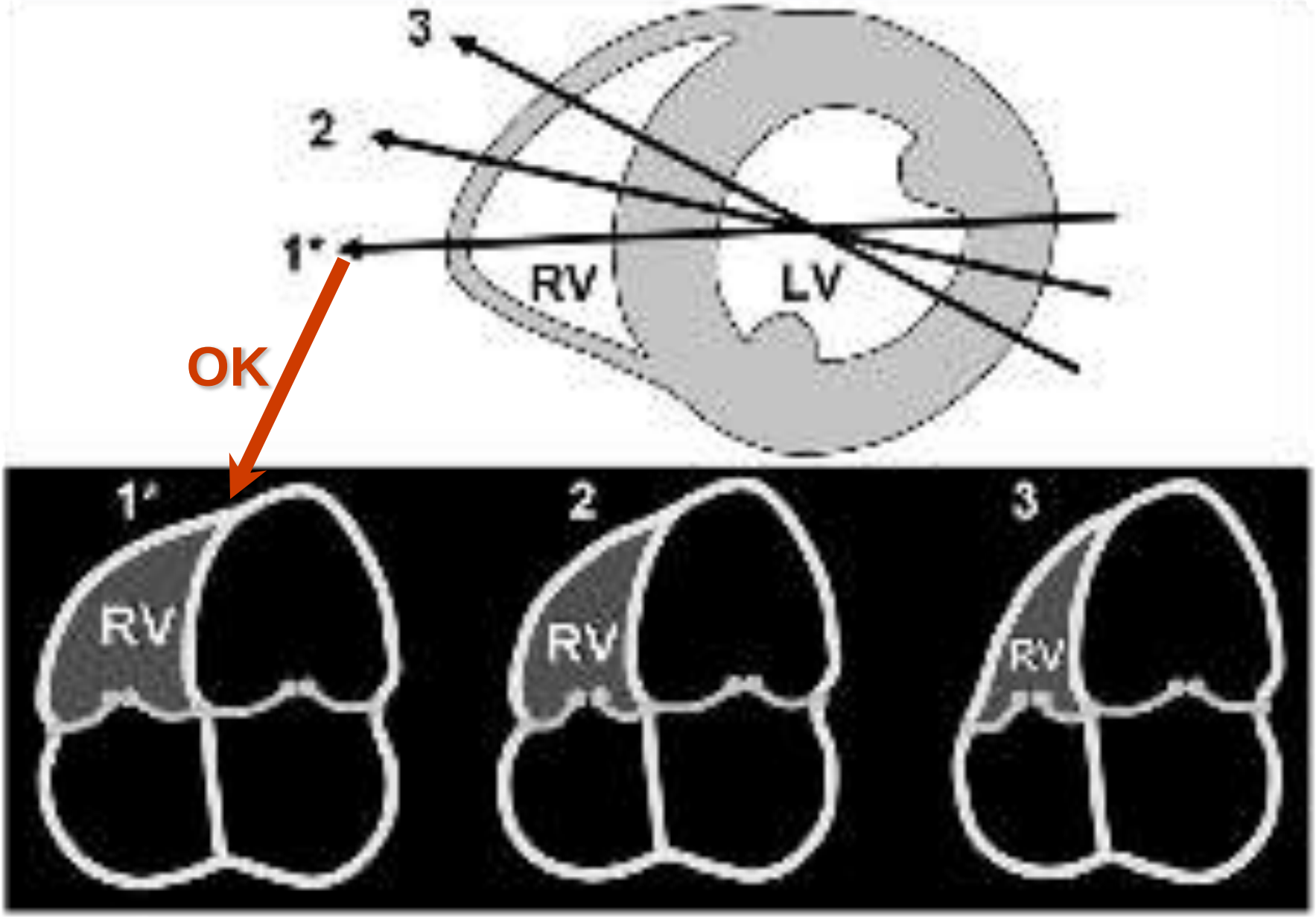


www.asecho.org

guidelines for the echocardiographic assessment of the right heart in adults

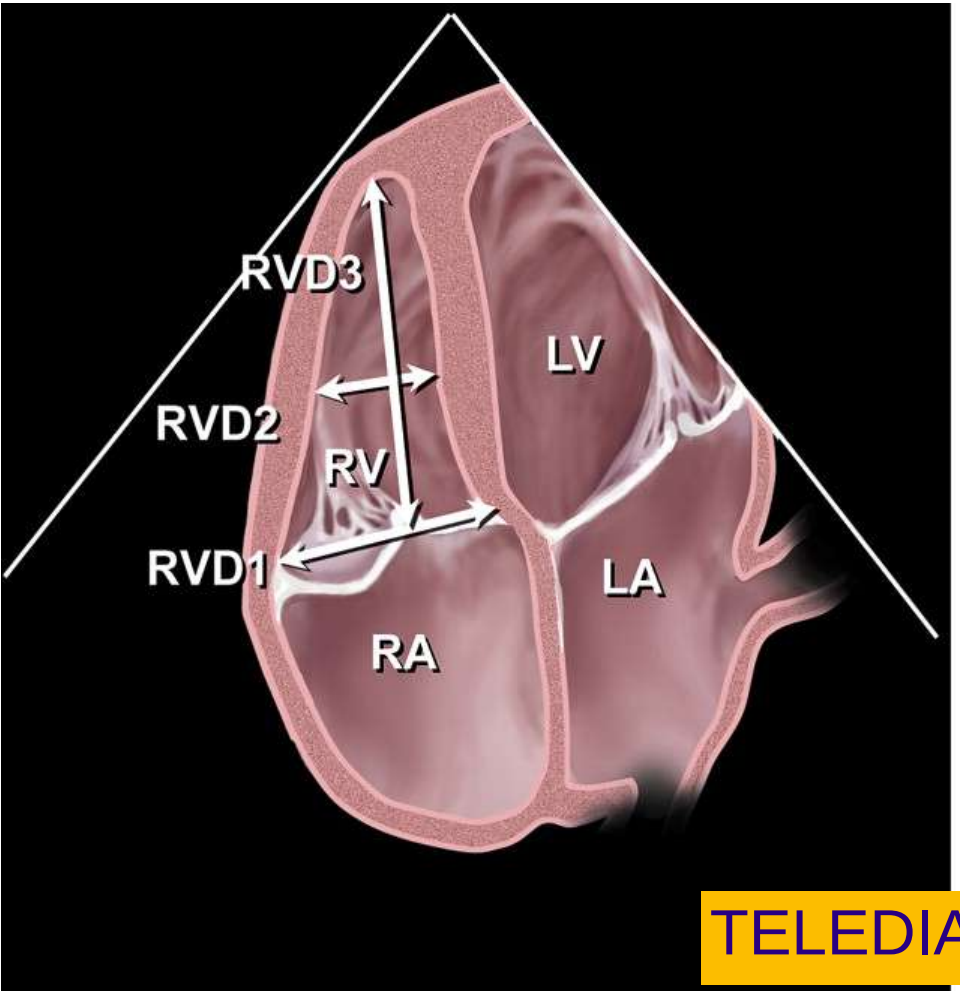
14 PROIEZIONI !

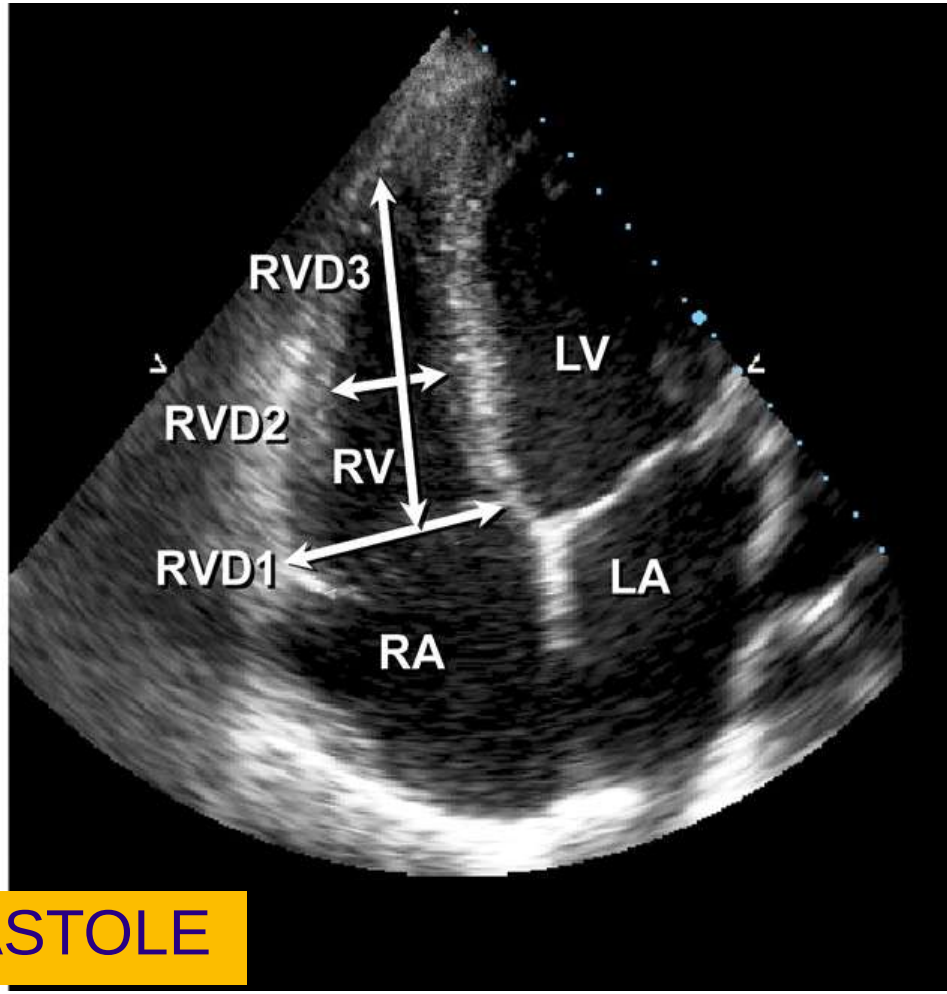
RIGHT VENTRICLE FOCUSED VIEW



Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

Diametro basale (annulus)	< 42 mm	(31-35 mm)
Diametro medioventricolare	< 35 mm	(23-33 mm)
Diametro longitudinale	< 86 mm	(67-75 mm)



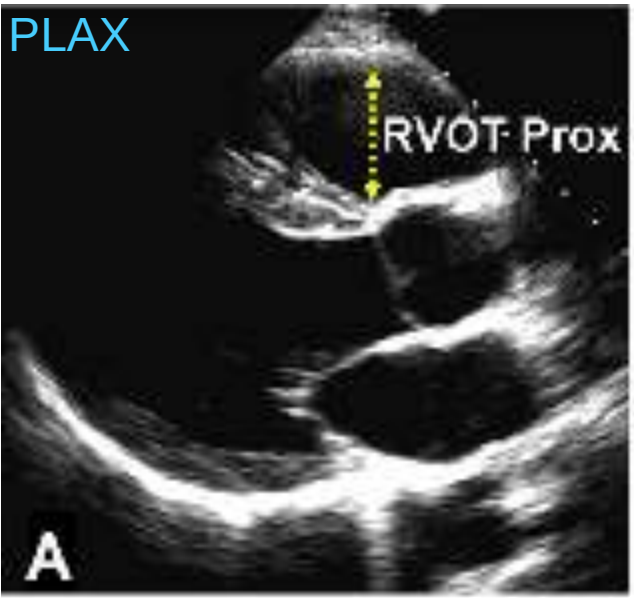


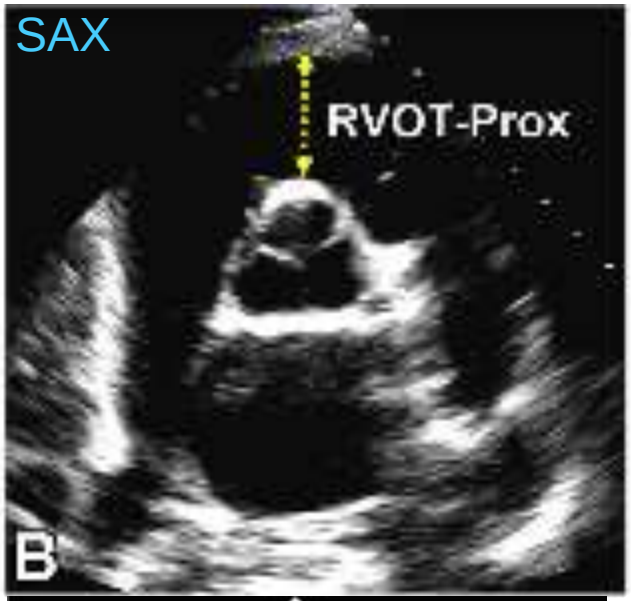
TELEDIASTOLE

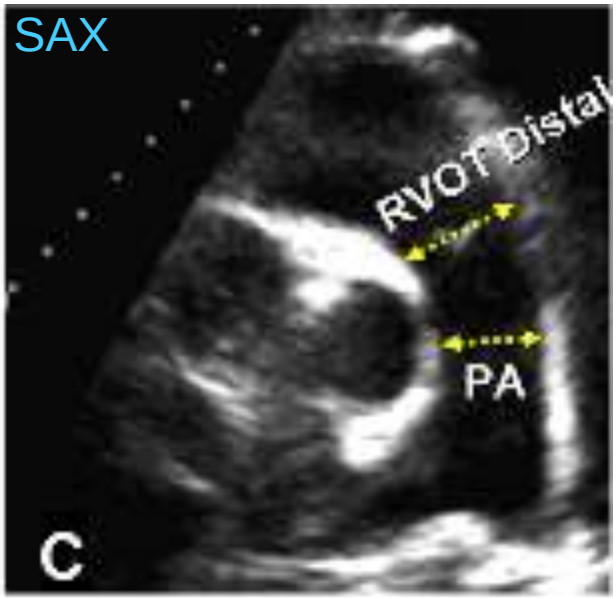
J Am Soc Echocardiogr 2010;23:685-713

Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

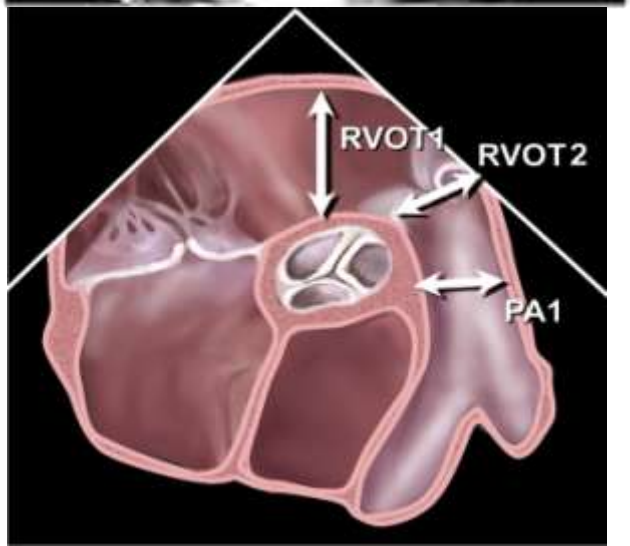
Diametro SAX RVOT distal (outflow)	< 27 mm (17-26 mm)
Diametro PLAX/SAX RVOT prox	< 33 mm (27-30 mm)







TELEDIASTOLE



J Am Soc Echocardiogr 2010;23:685-713

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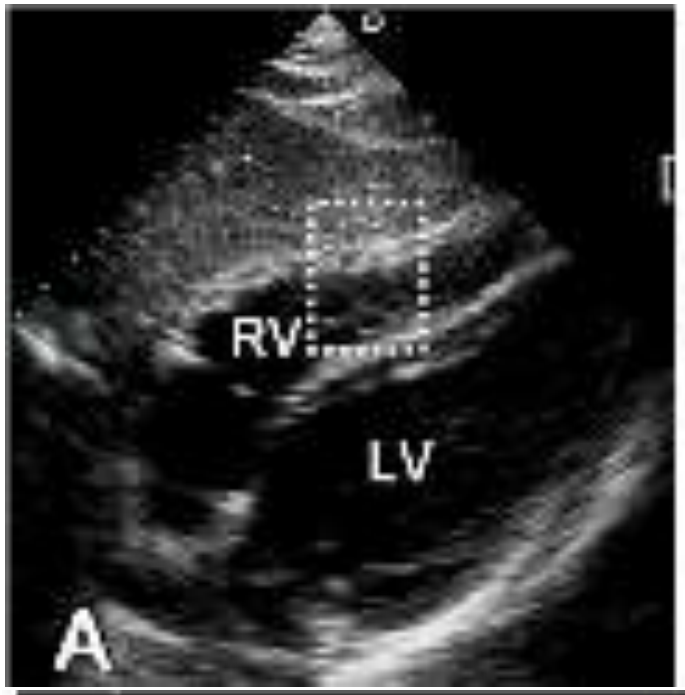
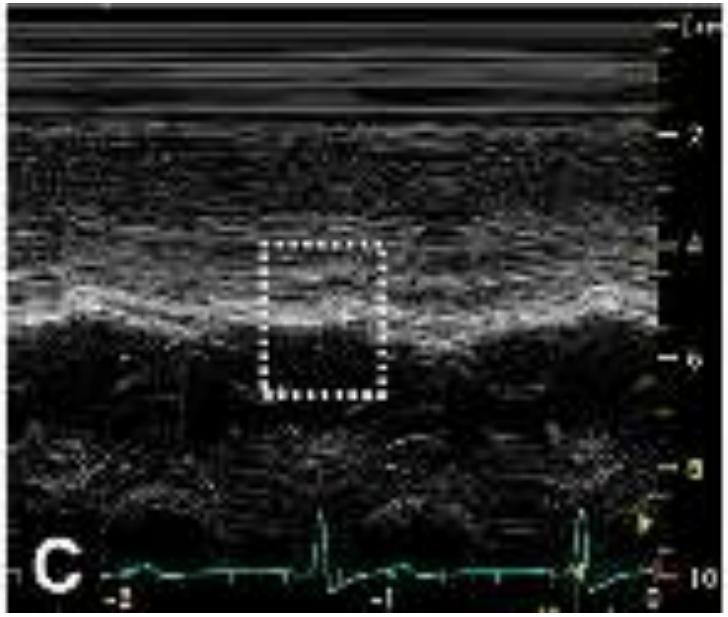




✓ Spessore > 5 mm indica sovraccarico pressorio
o
CMP ipertrofica/infiltrativa

✓ Escludere trabecole e grasso epicardico

✓ Attenzione al pericardio viscerale

✓ Meglio in fundamental imaging (disattivare II armonica)

INDICI DI FUNZIONE SISTOLICA VDX

- *FS RVOT*
- *VOLUME 2D*

} ***NON AFFIDABILI***

- **FAC**
- **TAPSE**
- **DOPPLER TISSUE IMAGING (DTI)**

} ***VALIDI***

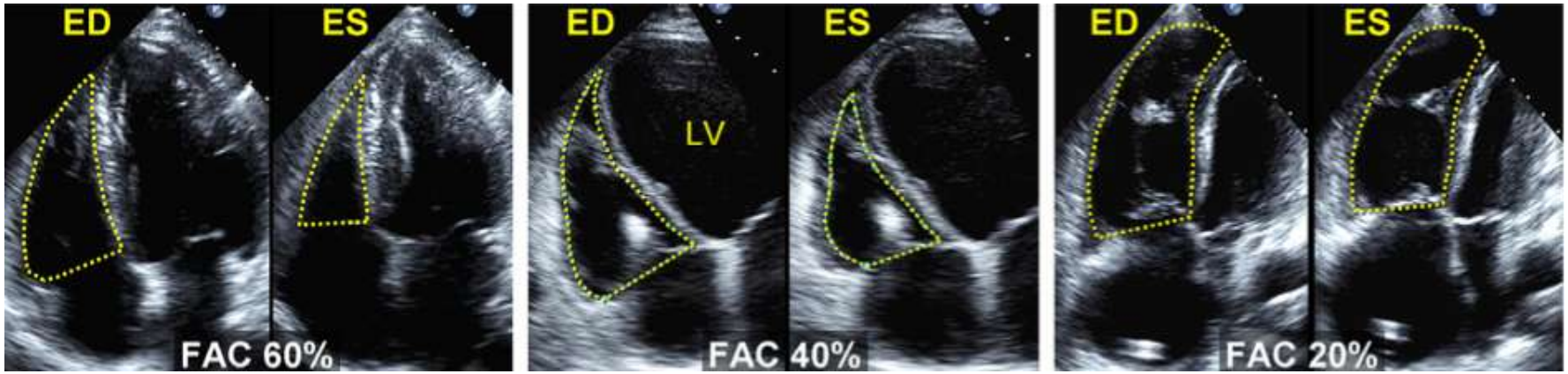
- **IMP *(PW o DTI)***
- **DP/dt**

} ***UTILI***

- **STRAIN/RATE/SPECKLE TRACKING**
- **3D**

} ***NUOVI***

3. FAC (FRACTIONAL AREA CHANGE)



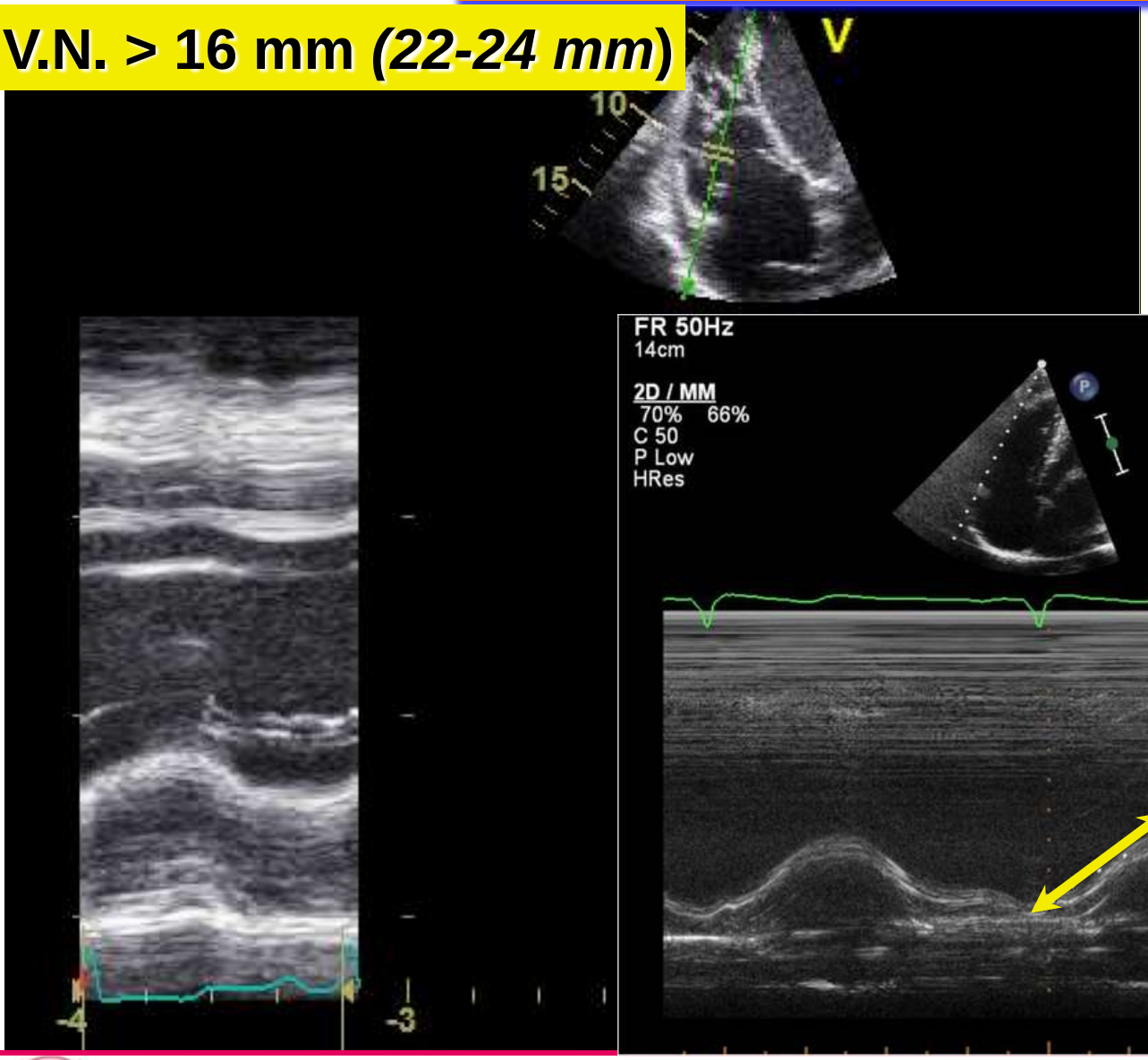
(Area diastolica - area sistolica) / area diastolica %

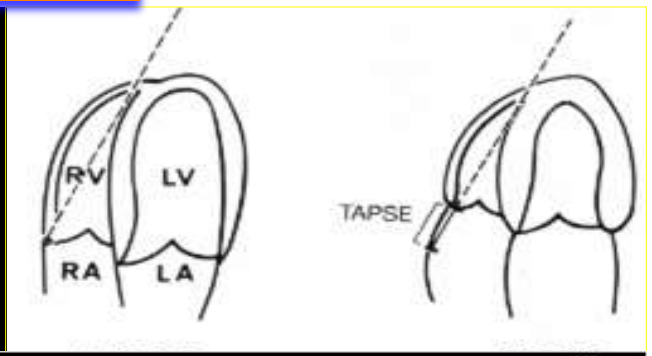
FAC ≤ 33% criterio maggiore per RVAD
sens. 55%, spec. 95%

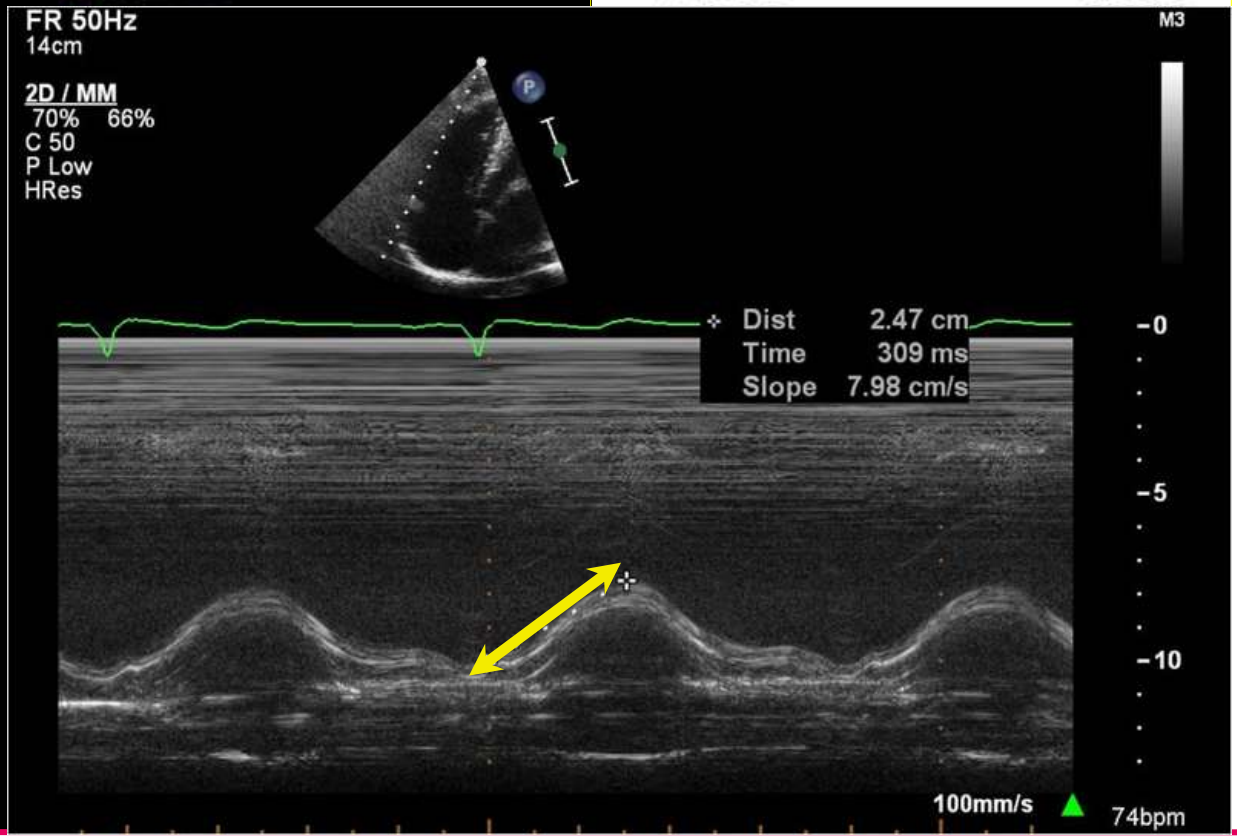
...ma ampia variabilità a seconda del taglio

4. TAPSE

V.N. > 16 mm *(22-24 mm)*







TISSUE DOPPLER IMAGING (TDI)

Sa: P < 0.00

Sa= peak systolic tricuspid annular velocity

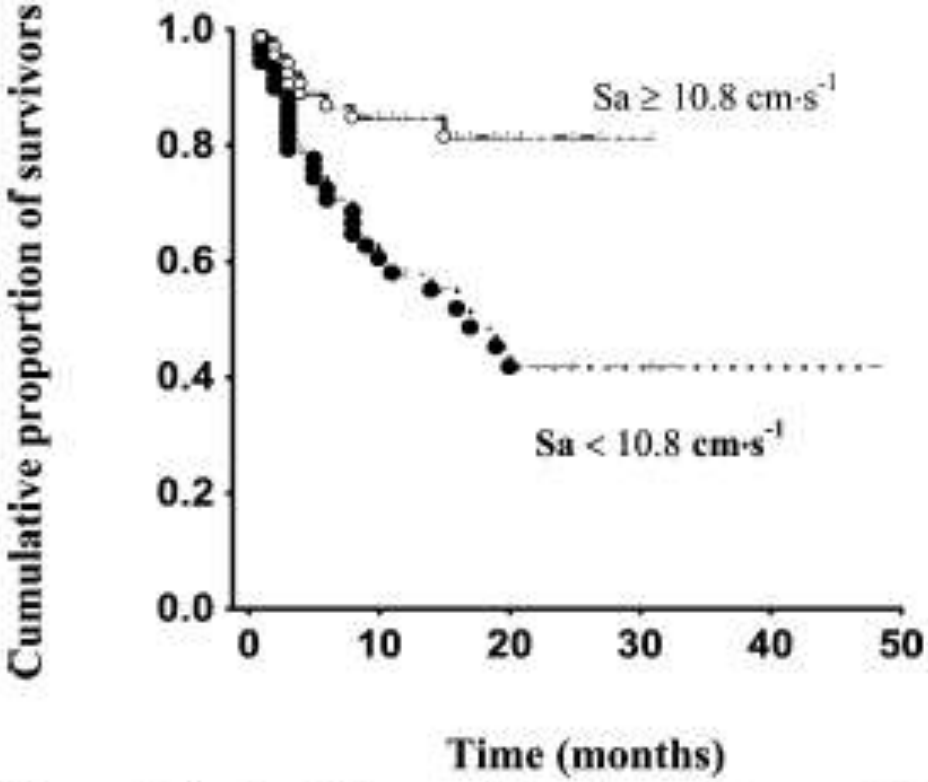
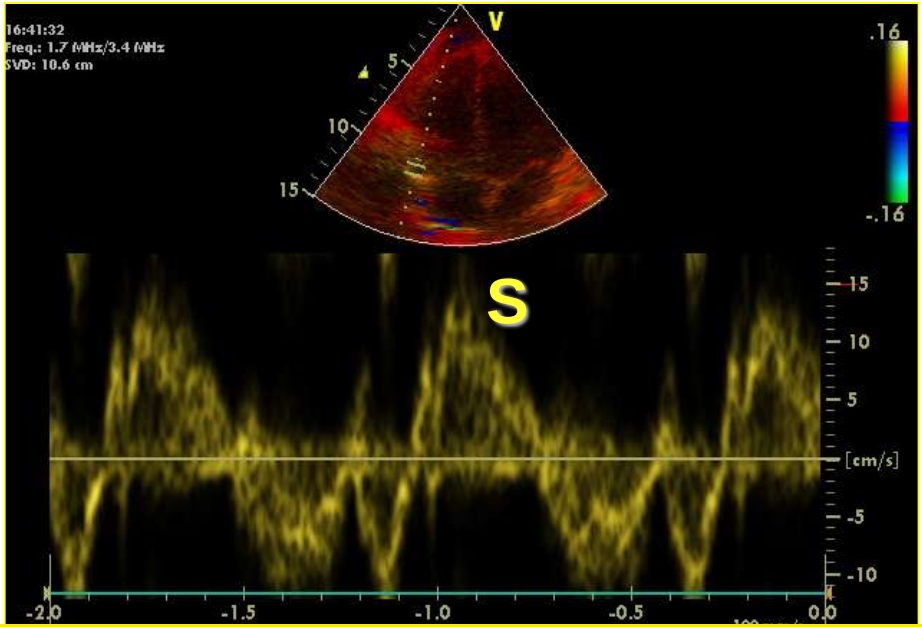


Figure 1. Kaplan–Meier analysis of event-free survival stratified according to the Sa (+: censored points). Sa = peak systolic tricuspid annular velocity.

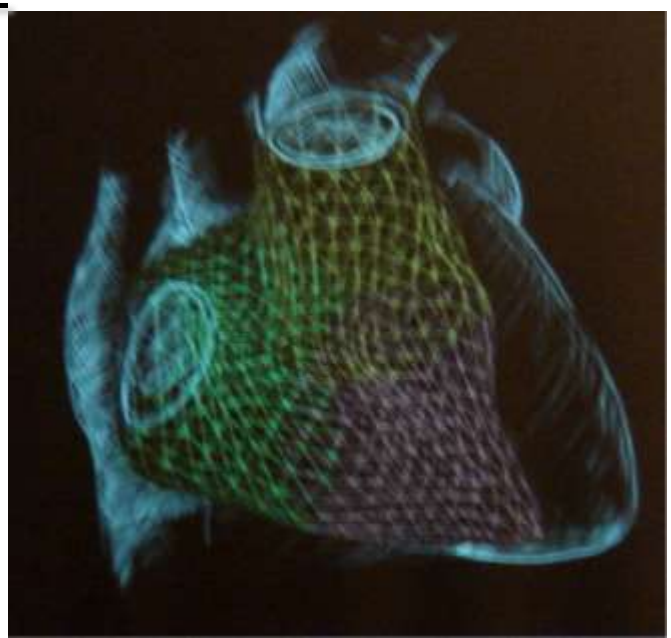


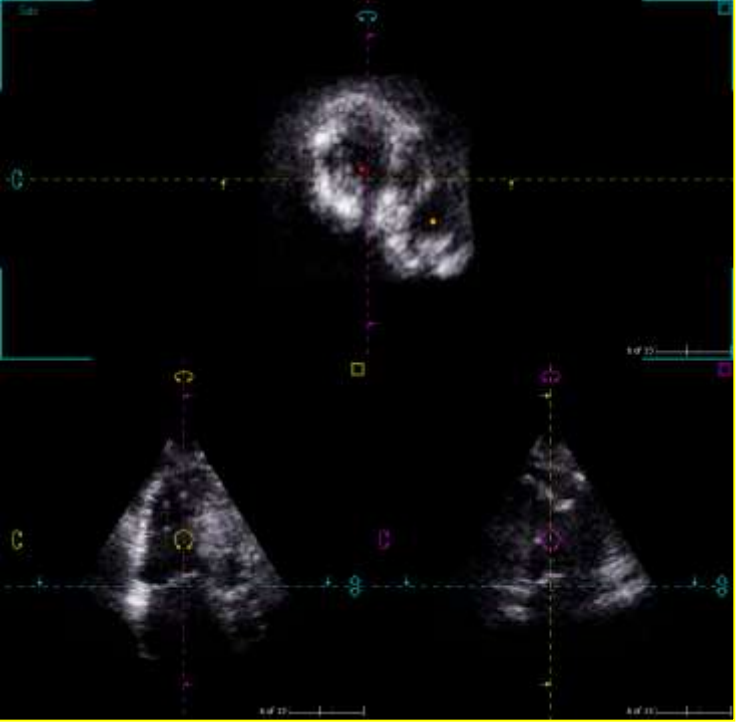
V.N. S > 10 cm/s *(14-15 cm/s)*

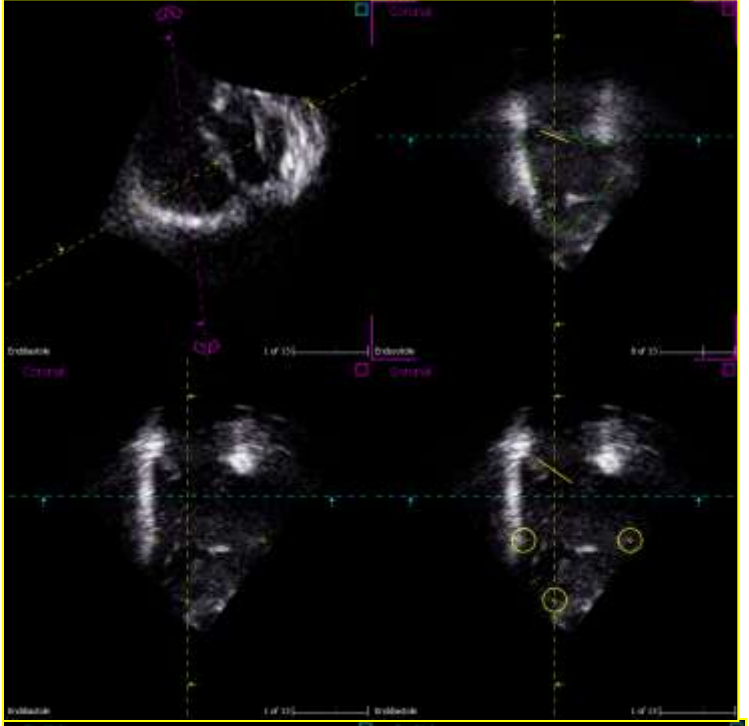
J. Meluzín
Eur J Echocardiography (2003) 4, 262–271

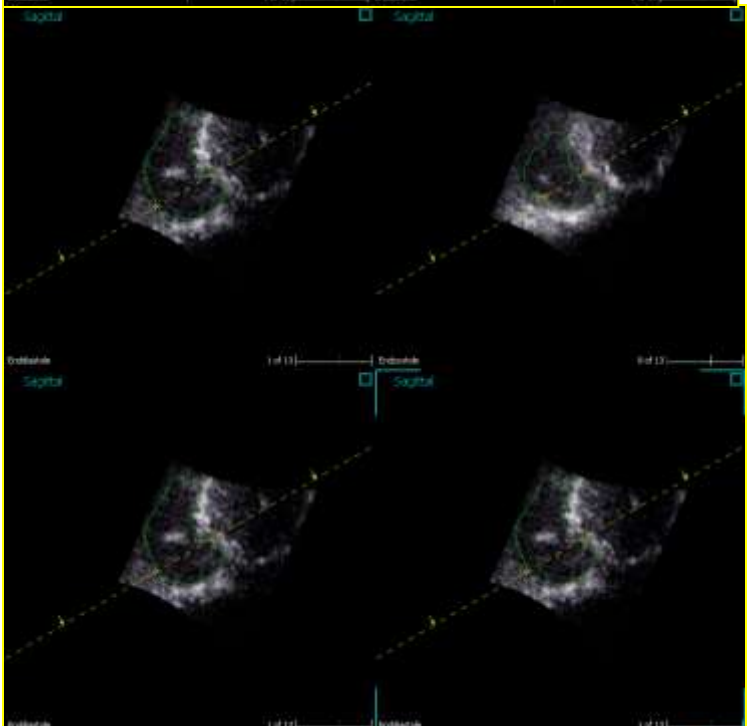
3D-ECHO

L ' ECHO 3D supera le limitazioni geometriche delle metodiche 2D mediante una stima dei volumi ottenuta grazie ad un reale data-set volumetrico 3D, senza ricorrere ad assunzioni geometriche



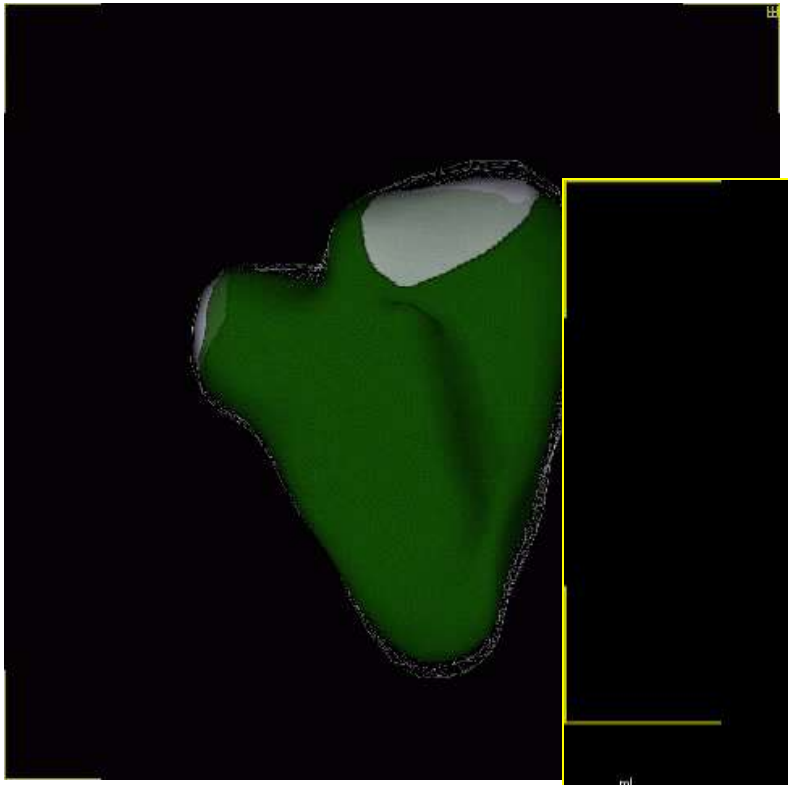


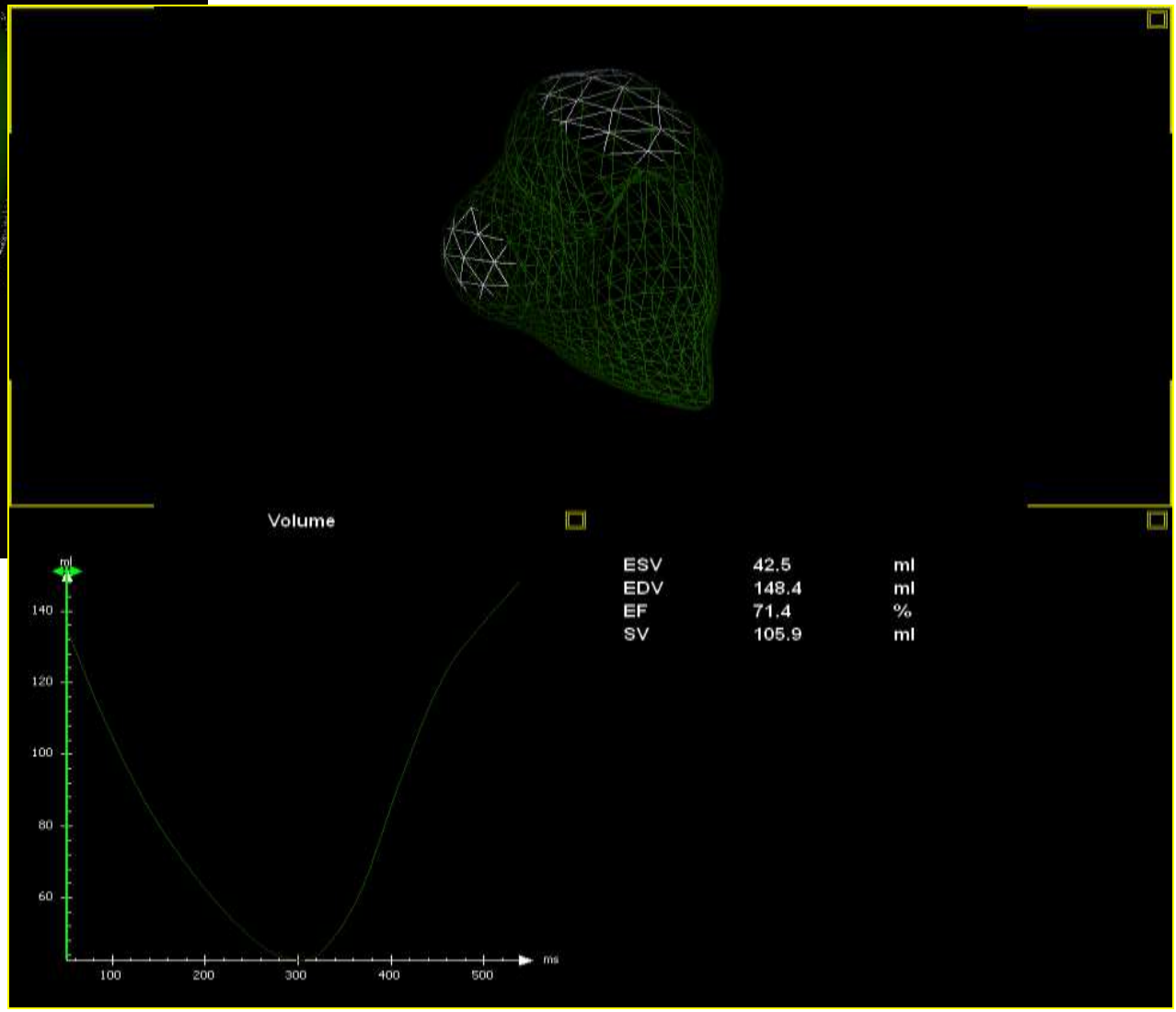




3 piani:

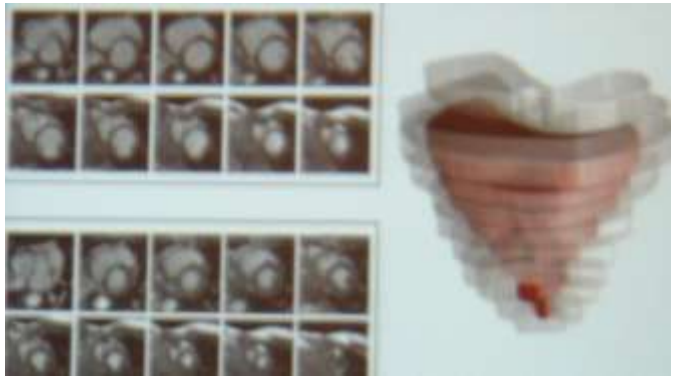
- CORONALE
- TRASVERSO
- SAGITTALE




Volume
ml
140
120
100
80
60
100
200
300
400
500
ms
ESV 42.5 ml
EDV 148.4 ml
EF 71.4 %
SV 105.9 ml

Dynamic assessment of Right Ventricular Volumes and Function by Real-Time Three-Dimensional Echocardiography: A Comparison Study With Magnetic Resonance Imaging in 100 Adult Patients

CONCLUSION: Right ventricular volumes and ejection fractions as assessed using RT3DE imaging compare well with MRI measurements. RT3DE imaging may become a time-saving and cost-saving alternative to MRI for the quantitative assessment of right ventricular size and function (JASE 2010)



J Am Soc Echocardiogr. 2010 Feb;23(2):134-40. doi: 10.1016/j.echo.2009.12.001.

Clinical value of real-time three-dimensional echocardiography for right ventricular quantification in congenital heart disease: validation with cardiac magnetic resonance imaging.

van der Zwaan HB, Helbing WA, McGhie JS, Geleijnse ML, Luijnenburg SE, Roos-Hesselink JW, Meijboom FJ.
Source

Department of Cardiology, Thoraxcenter, Erasmus University Medical Center, Rotterdam, The Netherlands. h.vanderzwaan@erasmusmc.nl

	3D-ECHO	MRI	VARIABILITÀ	
			Inter-obs	Intra-obs
$RVEDV_{ml}$	185 ± 71	219 ± 86	1 ± 15	1 ± 12
$RVESV_{ml}$	103 ± 48	114 ± 62	6 ± 17	7 ± 14
EF %	46 ± 8	49 ± 10	8 ± 13	6 ± 9

CONCLUSIONI

- ***ECOCARDIOGRAMMA METODICA DI SCREENING E FOLLOW-UP HP***
- ***PREDITTORE DI DISFUNZIONE VSN E SVILUPPO DI HP(?)***
  - ***Timing di follow-up?***
- ***ECHO 3D E STRAIN METODICHE EMERGENTI SU CUI PUNTARE***

Grazie per l’attenzione !