Nous abordatges en la hipertensió pulmonar

Novetats en el diagnòstic i avaluació: enfocats al ventricle dret

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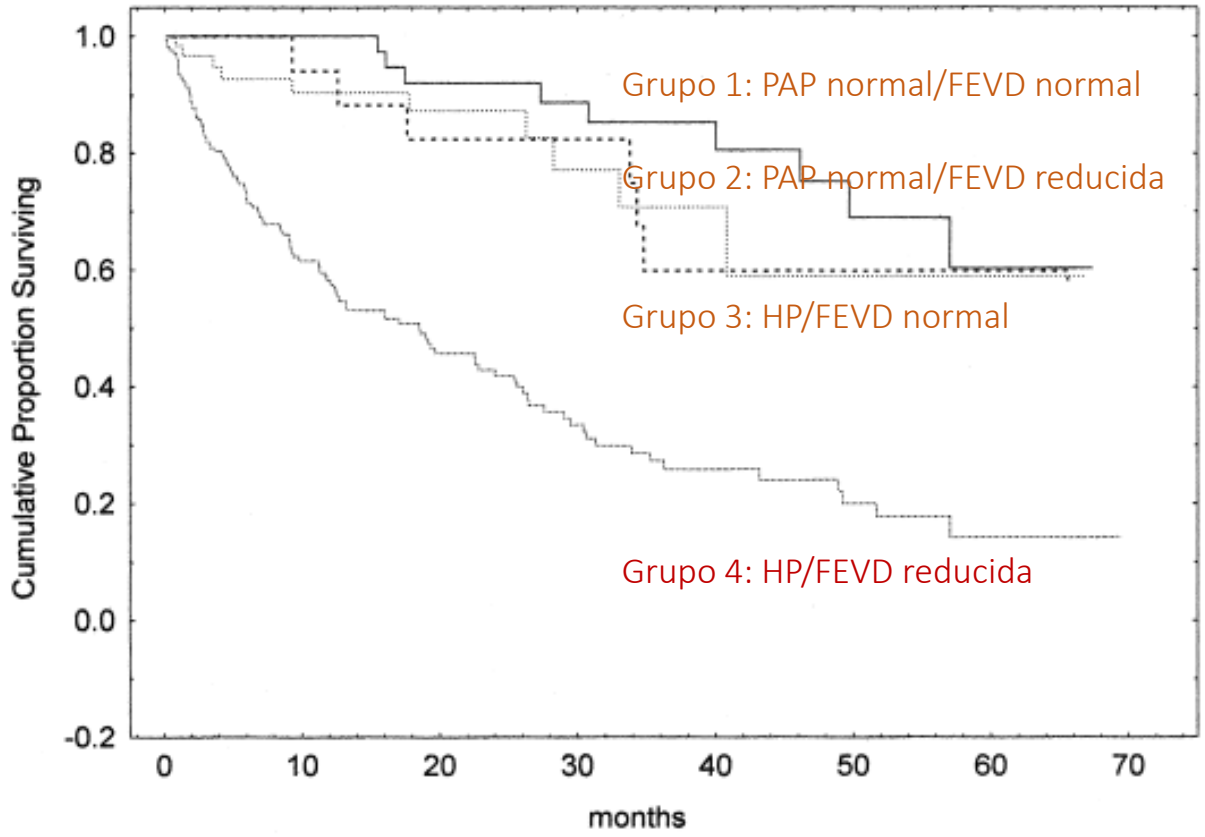
2 Març 2020

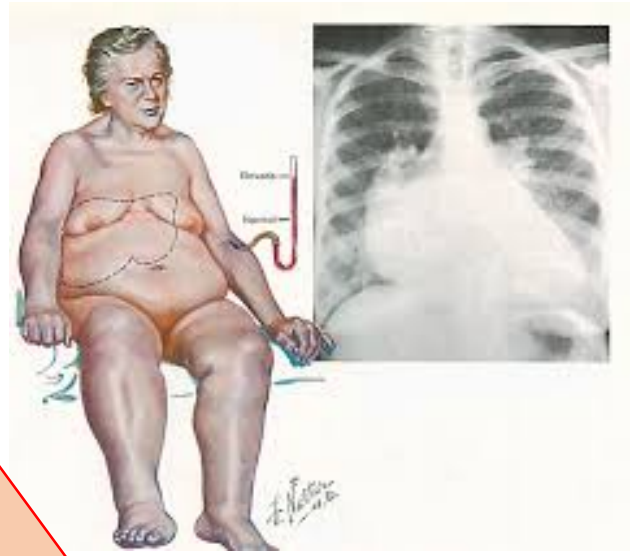
Hipertensión pulmonar & ventrículo derecho

- La hipertensión pulmonar (HP) es un estado hemodinámico que puede ser consecuencia de diferentes patologías.
- Globalmente su prevalencia es alta y se asocia a un mal pronóstico[1,2].
- El principal factor que determina la gravedad de los síntomas y la supervivencia en la HP es la capacidad del ventrículo derecho (VD) de adaptarse a la sobrecarga de presión[3].

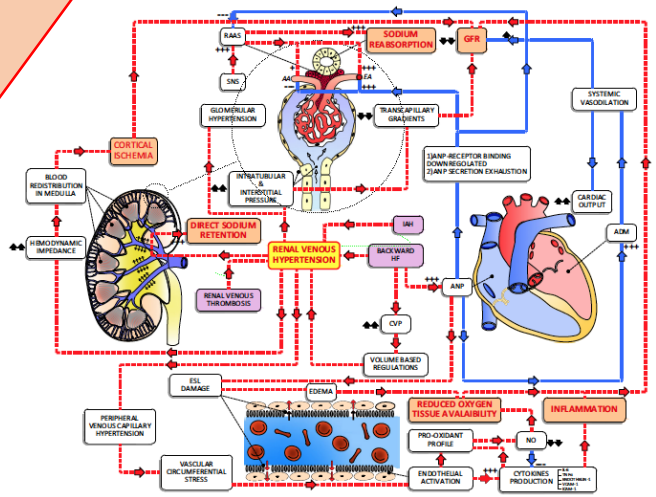


1. Galiè N et al. Eur Heart J. 2015.
2. McLaughlin VV, et al. JACC 2009.
3. Ghio S, et al. JACC 2001.

Progresión de la disfunción VD en la HP

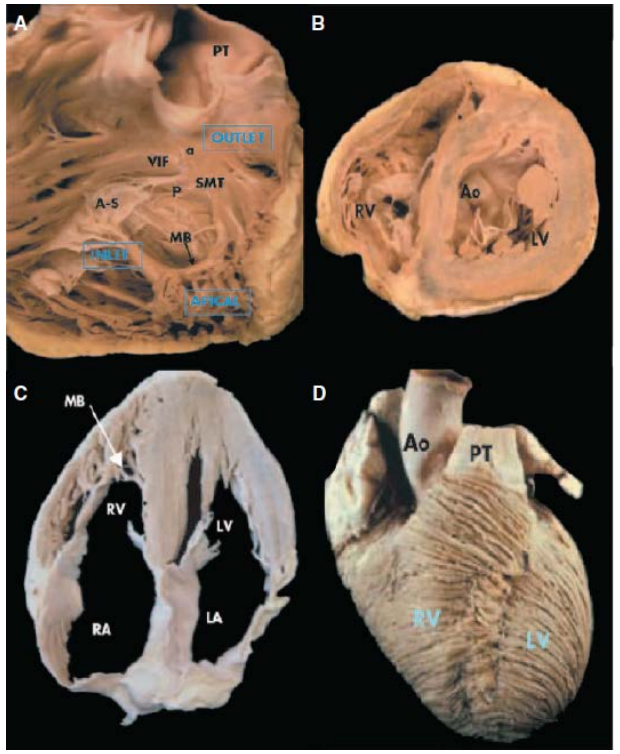


- Disfunción diastólica.
- Insuficiencia tricuspídea.
- Aumento de presión en AD.
- Congestión venosa.
- Hepatopatía, cirrosis.
- I renal.

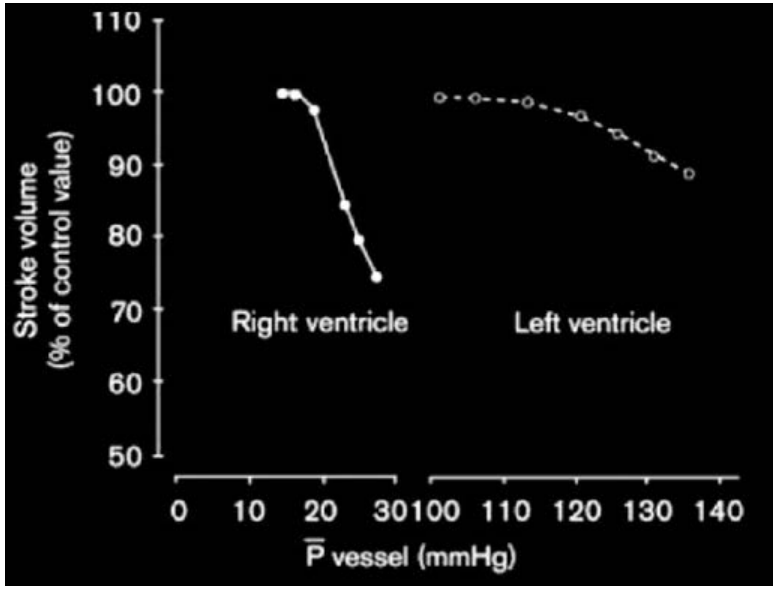


Características peculiares del VD

- Forma triangular.
- Pared fina.
- El acortamiento longitudinal es predominante.
- Apenas contribución de torsión o rotación.
- La contractilidad del VI contribuye al 30% de su sístole.
- Muy sensible al aumento agudo de postcarga.
- No hay una correlación exacta entre las PAP o RVP y disfunción VD.



Haddad. Circulation 2008



Macnee. Am J Respir Crit Care Med 1994

Parámetros y Scores hemodinámicos

- RVP e IC.
- PAD.
- PAD/PCP.
- PAPi=(sPAP-dPAP/PAD).
- RVSWI=(IC/FC)x(mPAP-PAD).
- EUROMACS (PAD/PCP pero PAPi también predictor).

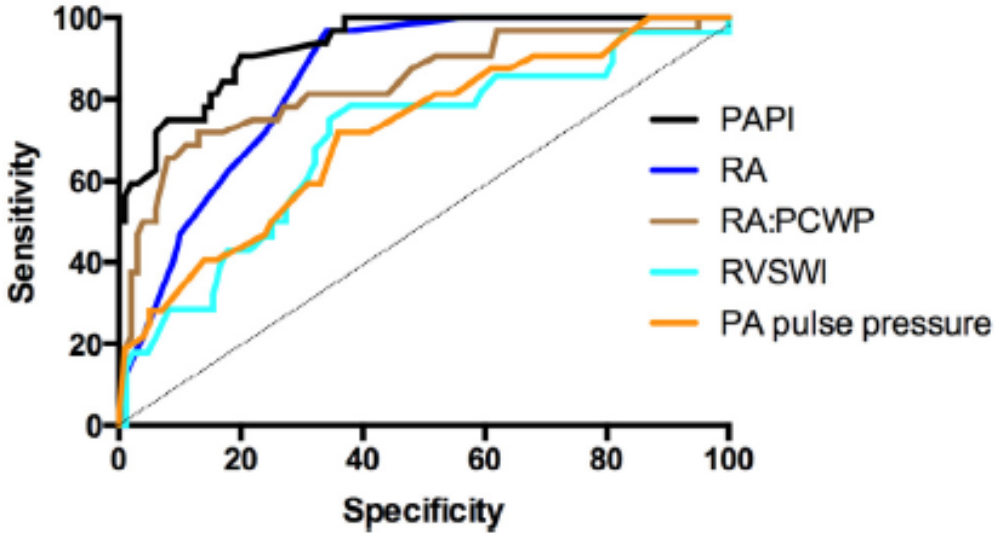
Valor predictor de dx VD post-LVAD de la PAPi

J Cardiac Fail 2016

Clinical Investigation

Pulmonary Artery Pulsatility Index Is Associated With Right Ventricular Failure After Left Ventricular Assist Device Surgery

KEVIN J. MORINE, MD, MICHAEL S. KIERNAN, MD, DUC THINH PHAM, MD, VIKRAM PARUCHURI, MD, DAVID DENOFRIO, MD, AND NAVIN K. KAPUR, MD



N=132

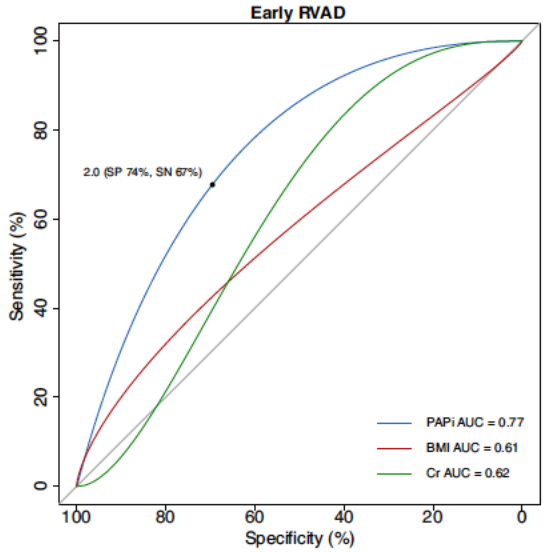
Dx VD (24%)= necesidad de RVAD y/o inotrópicos≥ 14d

PAPi <1.85: S=94%, E=81%

J Heart & Lung Transp 2016

Pulmonary artery pulsatility index predicts right ventricular failure after left ventricular assist device implantation

Guson Kang, MD,[a] Richard Ha, MD,[b] and Dipanjan Banerjee, MD, MS[a,c]



N=83

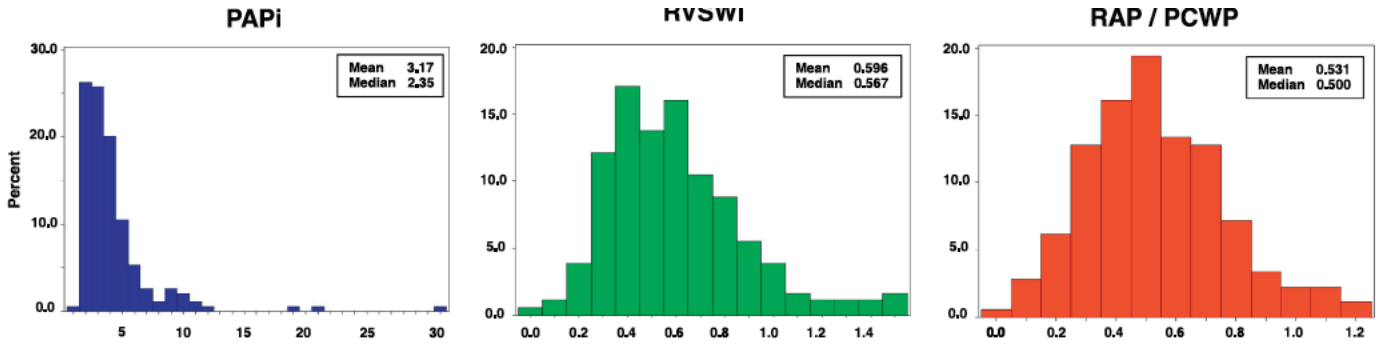
Dx VD (31%)= ↑ PVC & ↓ CI, necesidad de RVAD y/o NO≥ 1s; 11% necesitó RVAD.

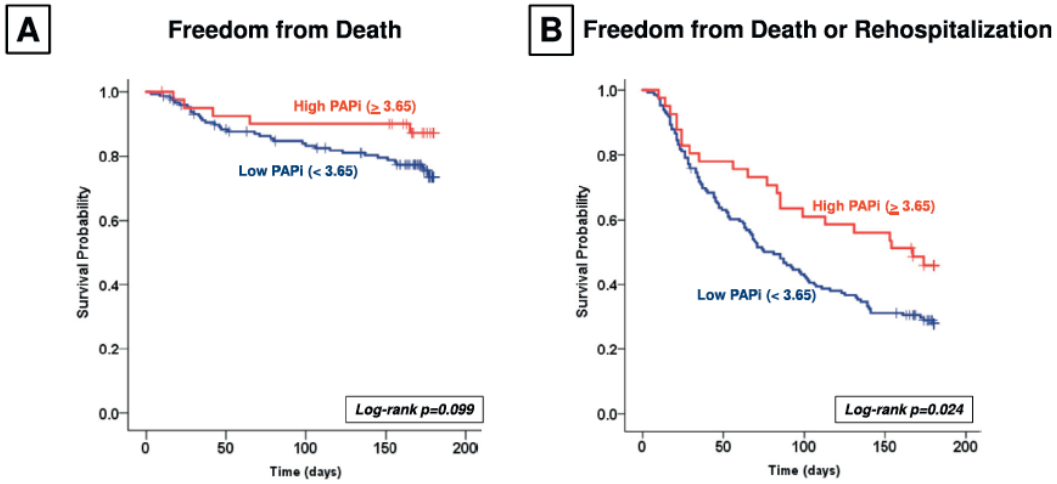
PAPi <2.00: S=67%, E=74%

Prognostic Impact of Pulmonary Artery Pulsatility Index (PAPi) in Patients With Advanced Heart Failure: Insights From the ESCAPE Trial

STEPHANIE MELLER KOCHAV, MD, RAUL J. FLORES, MD, LAUREN K. TRUBY, MD, AND VELI K. TOPKARA, MD

N= 433 pacientes NYHA IV; FEVI<30%.
Seguimiento 6m post-alta.
PAPi 3.65: S=83%, E=31%, VPP=71%





RV function indices				
PAPi	0.92 (0.85–0.99)	**.031**	0.91 (0.84–0.99)	**.022**
RA/PCWP ratio	1.27 (0.60–2.69)	.529		
RVSWI	1.26 (0.69–2.31)	.450		
RAP	1.02 (0.99–1.04)	.130		

Circulation

ORIGINAL RESEARCH ARTICLE

Derivation and Validation of a Novel Right-Sided Heart Failure Model After Implantation of Continuous Flow Left Ventricular Assist Devices

The EUROMACS (European Registry for Patients with Mechanical Circulatory Support) Right-Sided Heart Failure Risk Score

N= 2000 derivación; 988 validación.
Dx VD (22%)= necesidad de RVAD y/o inotrópicos≥ 14d y/o NO ≥48h.

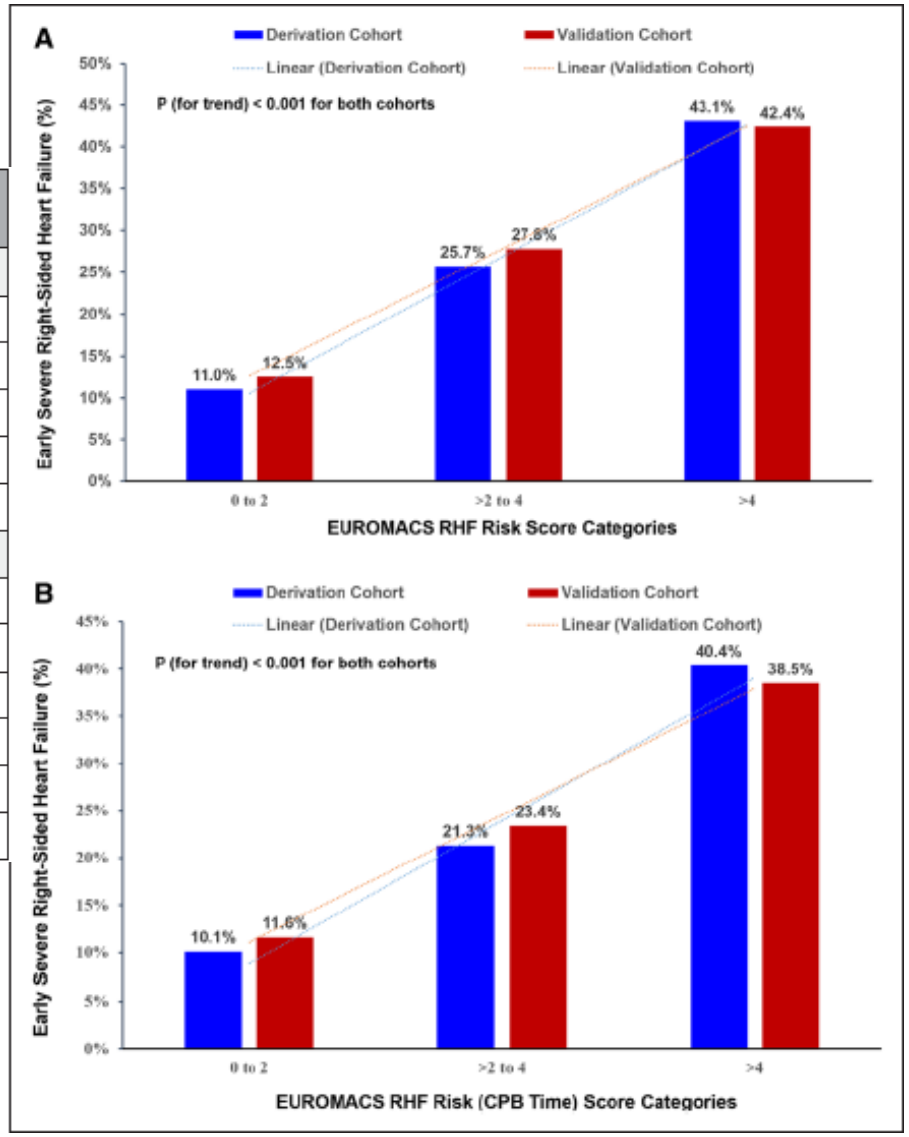
Hemodynamic characteristics		
Nonsinus vs sinus rhythm	1.202 (0.957–1.508)	0.11
Heart rate (≥96 vs <96 bpm)	1.445 (1.141–1.832)	0.002
Systolic blood pressure (≤85 vs >85 mm Hg)	1.623 (1.202–2.190)	0.002
Diastolic blood pressure (≤52 vs >52 mm Hg)	1.629 (1.199–2.213)	0.002
Cardiac index (≤1.2 vs >1.2 L/min)	0.817 (0.482–1.387)	0.46
PAP, systolic (≥53 vs <53 mm Hg)	1.220 (0.919–1.620)	0.17
PAP, diastolic (≥27 vs <27 mm Hg)	0.818 (0.617–1.085)	0.16
PAP, mean (≥35 vs <35 mm Hg)	0.967 (0.730–1.282)	0.82
RA pressure (≥11 vs <11 mm Hg)	1.729 (1.279–2.338)	0.001
PCWP (≥12 vs <12 mm Hg)	1.086 (0.649–1.819)	0.75
SVR (≥1488 vs <1488 mm Hg)	0.712 (0.479–1.059)	0.09
TPG (≥12 vs <12 mm Hg)	1.043 (0.758–1.436)	0.80
PVR (≥3.3 vs <3.3 mm Hg)	0.163 (0.027–0.983)	0.05
PAPI (≤1.6 vs >1.6)	2.175 (1.584–2.988)	<0.001
RVSWI (≤4.6 vs >4.6 g/m² per beat)	1.481 (1.051–2.086)	0.03
RA/PCWP (>0.54 vs ≤0.54)	2.075 (1.383–3.112)	<0.001

Derivation and Validation of a Novel Right-Sided Heart Failure Model After Implantation of Continuous Flow Left Ventricular Assist Devices

The EUROMACS (European Registry for Patients with Mechanical Circulatory Support) Right-Sided Heart Failure Risk Score

Variables	OR	Lower 95% CI	Upper 95% CI	χ^2 Value (χ^2=56.9)	Coefficients	Score
Preoperative model						
RA/PCWP >0.54	2.075	1.383	3.112	12.441	0.730	2
Hemoglobin ≤10 g/dL	1.611	1.037	2.502	4.506	0.477	1
Multiple intravenous inotropes	3.197	1.851	5.524	17.355	1.162	2.5
INTERMACS class 1–3	2.903	1.723	4.893	16.014	1.066	2
Severe RV dysfunction*	2.055	1.183	3.57	6.534	0.720	2
Postoperative RHF model after adding CPB time						
RA/PCWP >0.54	2.151	1.412	3.278	12.699	0.766	1
Hemoglobin ≤10 g/dL	2.609	1.544	4.409	12.839	0.959	1.5
Multiple intravenous inotropes	3.013	1.712	5.302	14.635	1.103	2
INTERMACS Class 1–3	3.393	1.946	5.915	18.561	1.222	2
Severe RV dysfunction*	2.099	1.193	3.694	6.618	0.742	1
CPB time >100 min	2.032	1.296	3.184	9.562	0.709	1

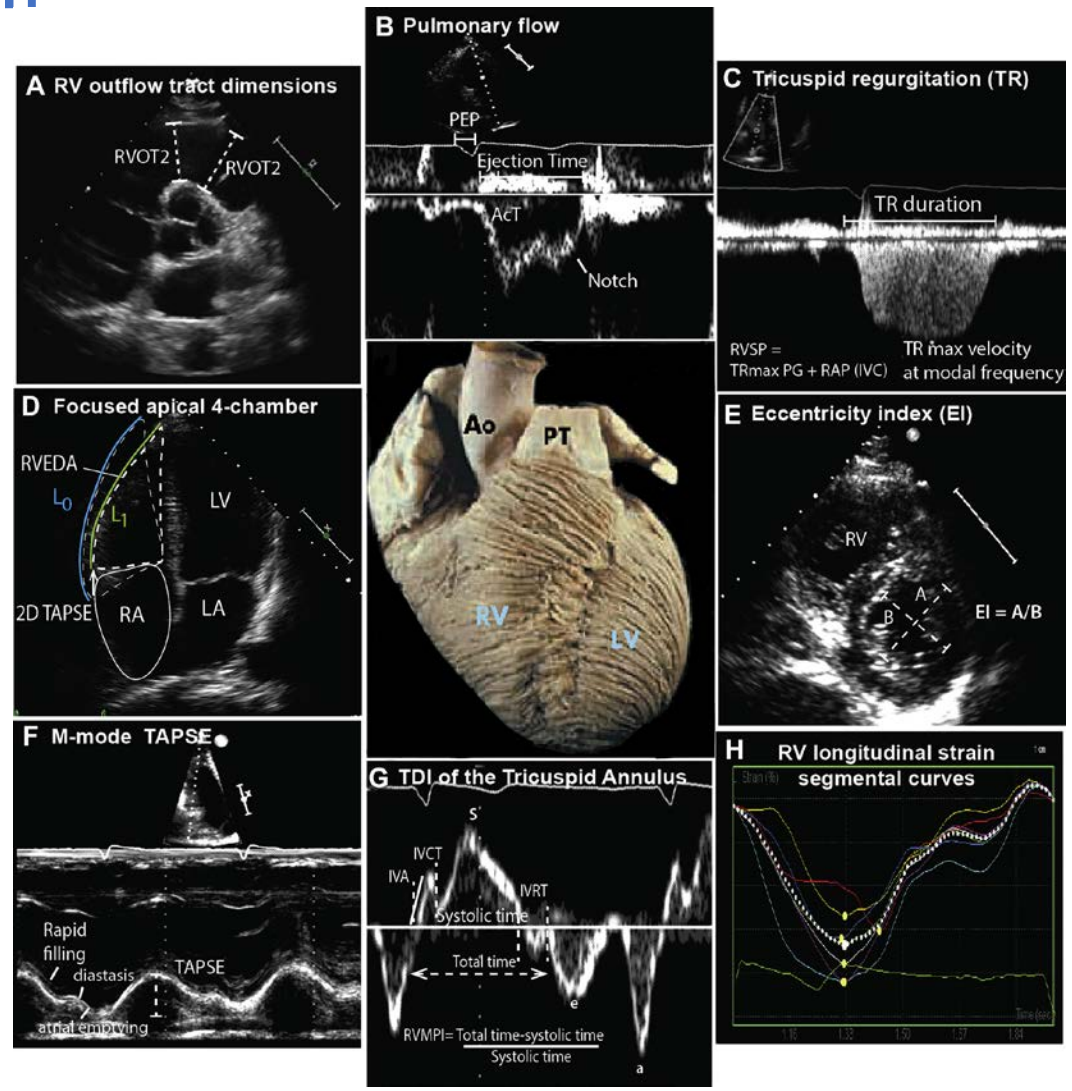
PAPi no incluida por colinealidad



AUC=0.67

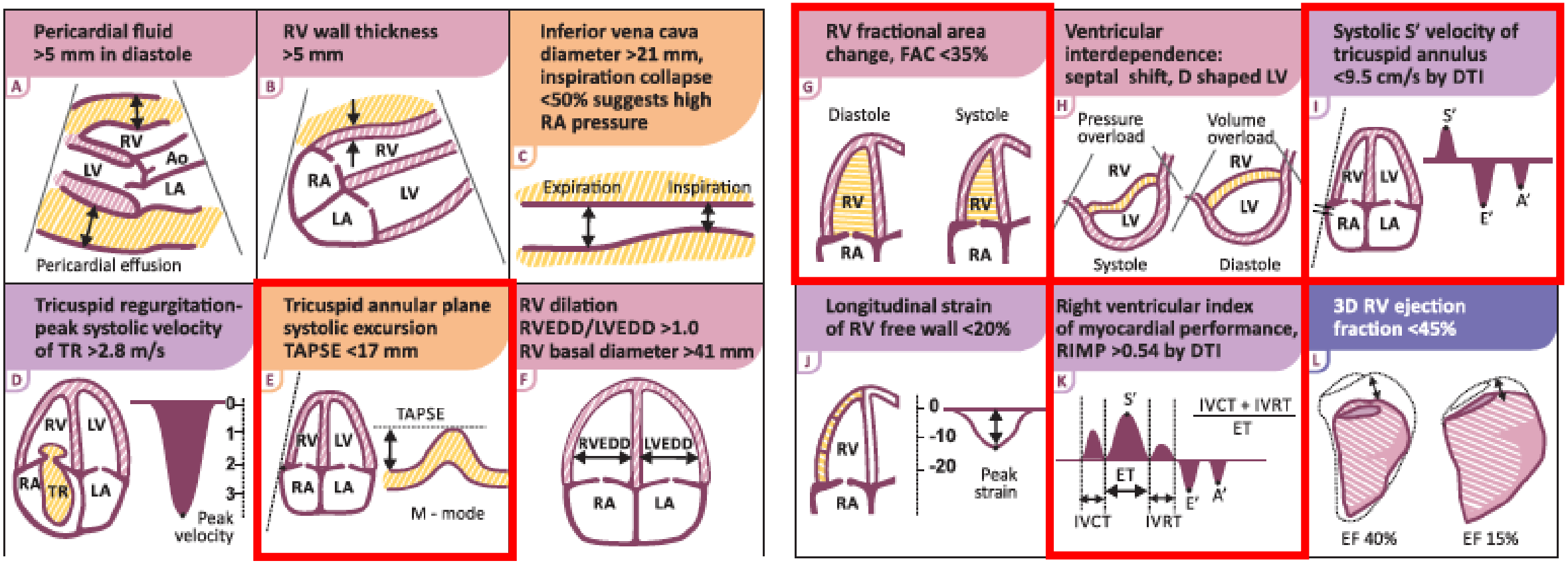
La función del VD en la HP

- Técnica de imagen más extendida para evaluar la probabilidad de HP y la función del VD.
- Limitaciones:
  - Ausencia de IT.
  - Forma compleja piramidal.
  - Localización retroesternal.
  - Difícil delineación del endocardio.
  - Índices dependientes de carga.



Amsallem et al. JACC HF 2018.

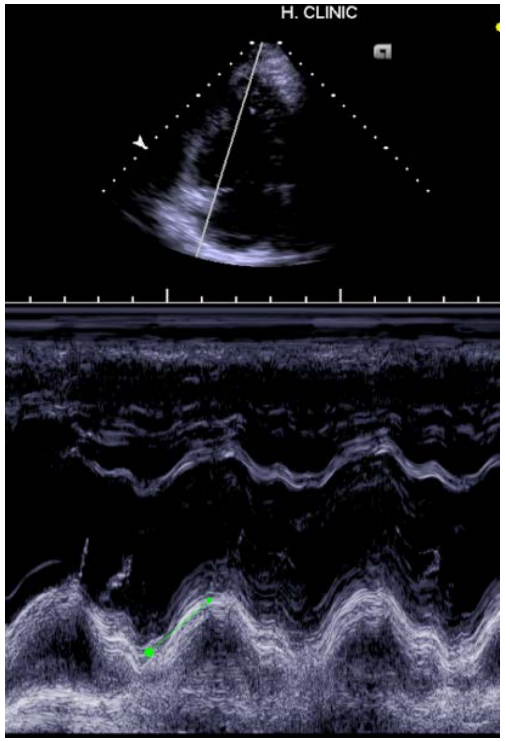
Ecocardiografía



Harjola et al. Eur Heart J 2016

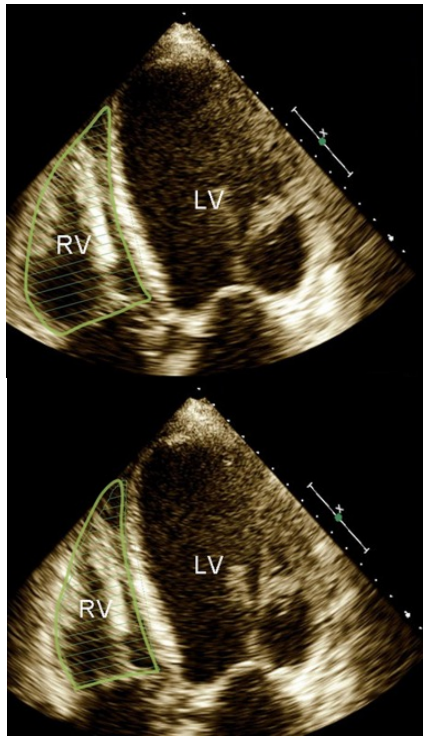
Recomendados por la Soc Americana de Ecocardiografía & Soc Europea de Imagen Cardiovascular

Ecocardio: **evaluación del VD**



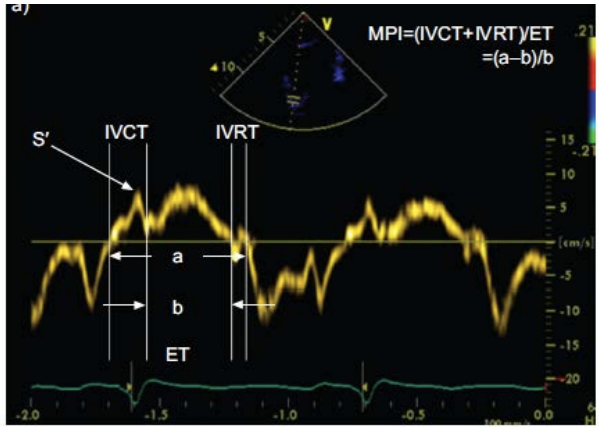
TAPSE

20 mm -> FEVD ≈ 50%
15 mm -> FEVD ≈ 40%
10 mm -> FEVD ≈ 30%
5 mm -> FEVD ≈ 20%



Cambio de área fraccional

Buena correlación con FEVD

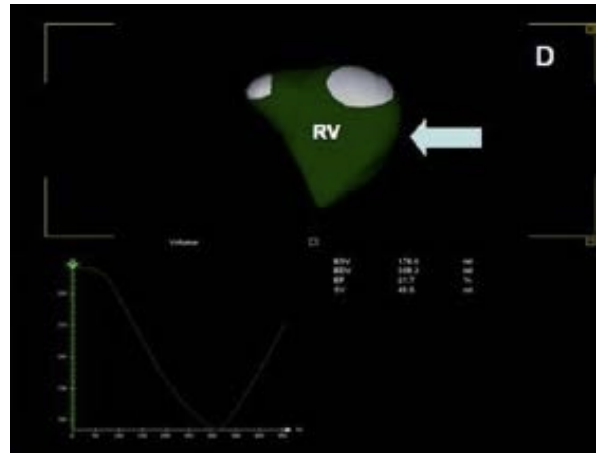


RIMP

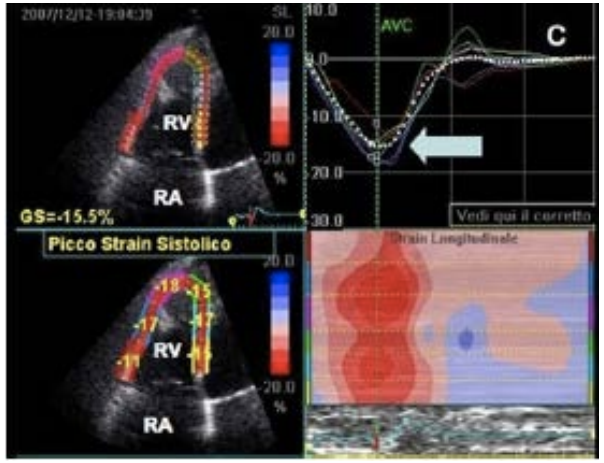
= IVCT+IVRT/ET
(relación tiempos isovolumétricos & tiempo de eyección)

Normal= 0.28± 0.04
< Dependiente de pre & post-carga y FC

S' < 11.5 cm/s= disfunción VD con sen 85% & esp 90%.



Eco 3D



Strain longitudinal

Valor pronóstico de las medidas ecocardiográficas de función del VD en HP

First Author, *Journal*, Year	Population	n	Design	Metrics	Conclusions
Pulmonary hypertension					
Forfia et al., *Am J Respir Crit Care Med*, 2006	Group 1, 3, 4 PH	63	Prospective	TAPSE	TAPSE <18 mm was associated with 4-fold increased risk of death during follow-up.
Fine et al., *Circ Cardiovasc Imaging*, 2013	Group 1, 3, 4 PH vs. no PH	406 vs. 169	Prospective	RVLS	Large study on prognostic value of RV strain in PH. Multivariate model: NYHA functional class, strain, NT-proBNP for death at 18 months.
Ryo et al., *Circ Cardiovasc Imaging*, 2015	Pre-capillary PH	92 vs. 20	Prospective	RVESVI 3D RVLS	3D echocardiography study showing prognostic value of RVESVI (≥114 ml/m^2) for PH-related hospitalization, death, or lung transplantation or endarterectomy at 6 months.
Amsallem et al., *Circ Cardiovasc Imaging*, 2017	PAH	228	Prospective	RV end-systolic area and remodeling index RVLS	Comparative study showing the equivalent prognostic value of RV end-systolic remodeling index, NYHA functional class, NT-proBNP to validated risk scores, such as the REVEAL score.

Amsallem. JACC Heart Fail2018

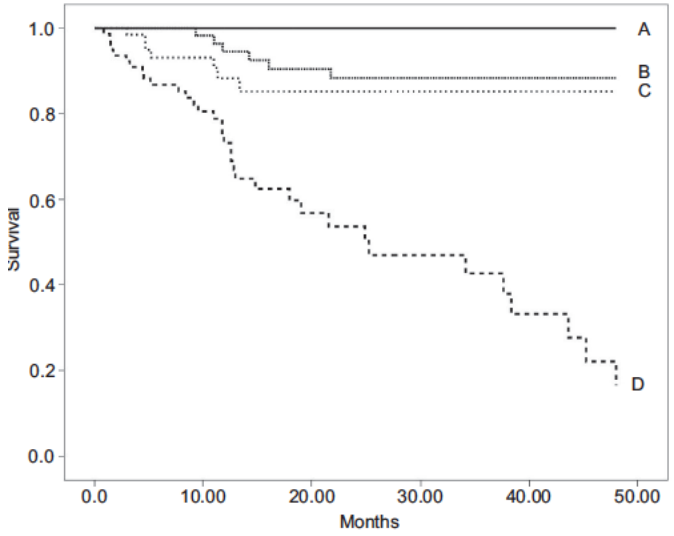
Acoplamiento VD-AP por eco

Am J Physiol Heart Circ Physiol 305: H1373–H1381, 2013.
First published August 30, 2013; doi:10.1152/ajpheart.00157.2013.

Tricuspid annular plane systolic excursion and pulmonary arterial systolic pressure relationship in heart failure: an index of right ventricular contractile function and prognosis

M. Guazzi,[1] F. Bandera,[1] G. Pelissero,[1] S. Castelvecchio,[1] L. Menicanti,[2] S. Ghio,[3] P. L. Temporelli,[4] and R. Arena[5]

N=293 ICpEF o ICrEF
Pronóstico por terciles



Validation of the Tricuspid Annular Plane Systolic Excursion/Systolic Pulmonary Artery Pressure Ratio for the Assessment of Right Ventricular-Arterial Coupling in Severe Pulmonary Hypertension

See Editorial by Bashline and Simon

Khodr Tello, MD

Circulation: Cardiovasc Imaging 2019

N=52
Comparación con Ees/Ea (curvas presión volumen)
Predictor independiente (TAPSE/PASP<0.31 mm/mmHg) intra & validación externa (N=192).

RV Contractile Function and its Coupling to Pulmonary Circulation in Heart Failure With Preserved Ejection Fraction

Stratification of Clinical Phenotypes and Outcomes

Marco Guazzi, MD, PhD,[a,b] Debra Dixon, BS,[c] Valentina Labate, MD,[a,b] Lauren Beussink-Nelson, RDCS, MHS,[c] Francesco Bandera, MD,[a,b] Michael J. Cuttica, MD,[d] Sanjv J. Shah, MD[c,e]

JACC Cardiovasc Imaging 2017

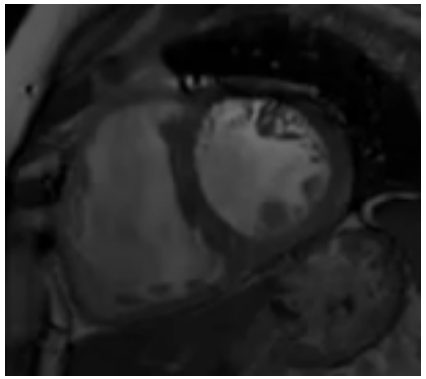
Right ventricle to pulmonary artery coupling in patients undergoing transcatheter aortic valve implantation

Ibrahim Sultan,[1,2] Arturo Cardounel,[1,2] Islam Abdelkarim,[2] Arman Kilic,[1,2]

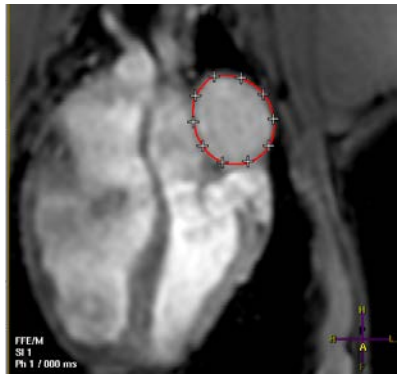
Heart 2019

Utilidad de la RMC en la HP

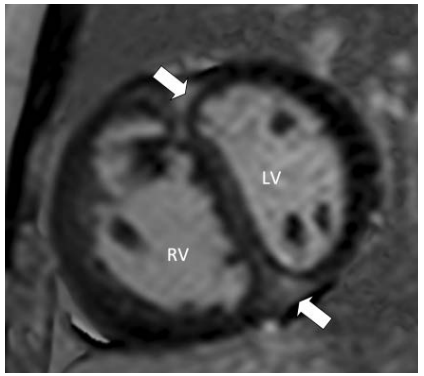
Cine (SSFP)



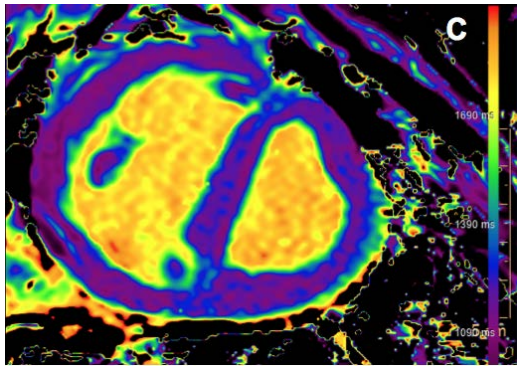
Contraste de fase (AP)



Realce tardío

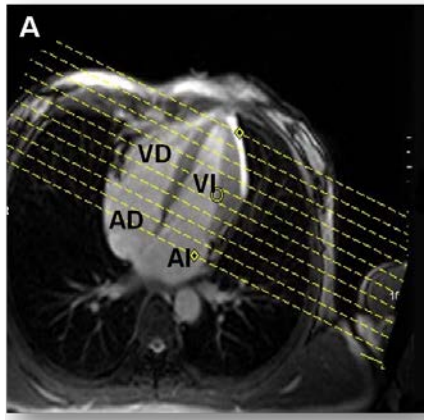


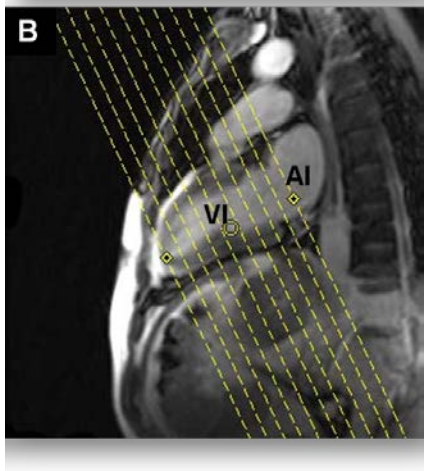
T1 mapping



RMC: Secuencias de cine.

- La RMC es la técnica *gold stand*ard para el cálculo de volúmenes y FEVD.
- Adquisición:





- ✓ Volúmenes y FE biventricular.
- ✓ Masa biventricular.
- ✓ Contractilidad segmentaria VD.
- ✓ Curvatura del SIV.

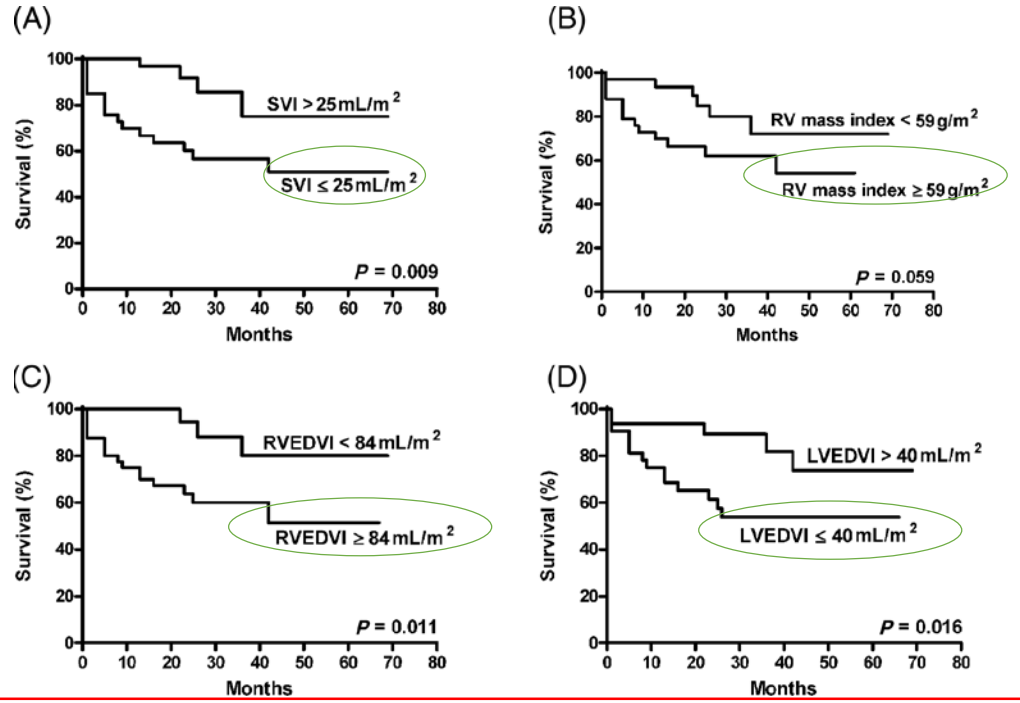
European Heart Journal (2007) 28, 1250–1257
doi:10.1093/eurheartj/ehl477

Clinical research
Hypertension

Prognostic value of right ventricular mass, volume, and function in idiopathic pulmonary arterial hypertension

Serge A. van Wolferen[1], Johannes T. Marcus[2], Anco Boonstra[1], Koen M.J. Marques[3], Jean G.F. Bronzwaer[3], Marieke D. Spreeuwenberg[4], Pieter E. Postmus[1], and Anton Vonk-Noordegraaf[1*]

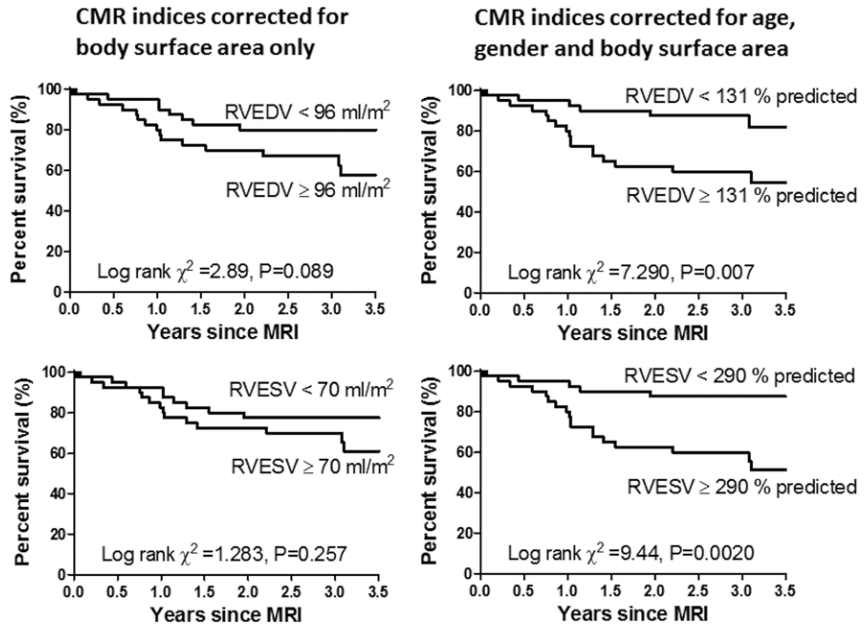
- 64 pts con iPAH y tratamiento VD.
- 1 centro (VUmc Amsterdam).
- RMC, RHC y T6m basal y 1 año.
- Seguim. 32 m, 19 exitus.
- Predictores independientes de mortalidad:
  - RMC: ↑VTDVD, ↓VTDVI, ↓GC.
  - RHC: PVRi; y CF NYHA



Prognostic Value of Cardiovascular Magnetic Resonance Imaging Measurements Corrected for Age and Sex in Idiopathic Pulmonary Arterial Hypertension

Andrew J. Swift, PhD; Smitha Rajaram, FRCR; Michael J. Campbell, PhD; Judith Hurdman, MRCP; Steve Thomas; Dave Capener, MSc; Charlie Elliot, MRCP; Robin Condliffe, MD; Jim M. Wild, PhD; David G. Kiely, MD

- 80 pts con iPAH y RMC + RHC 1 centro (Sheffield).
- Seguim. 32 m, 23 exitus.
- RVESVi predictor independiente de parámetros invasivos: PADm, IC, vO2.

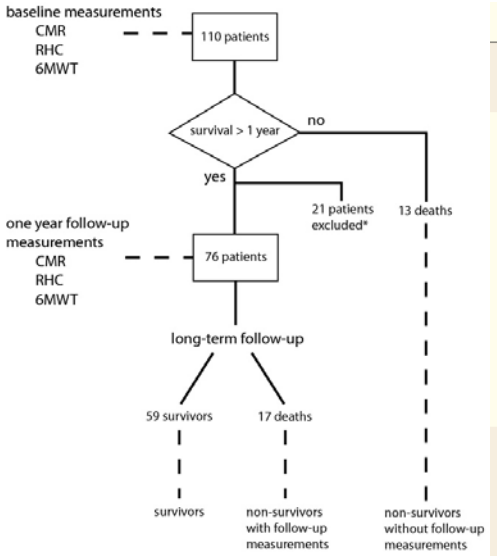


Journal of the American College of Cardiology
© 2011 by the American College of Cardiology Foundation
Published by Elsevier Inc.

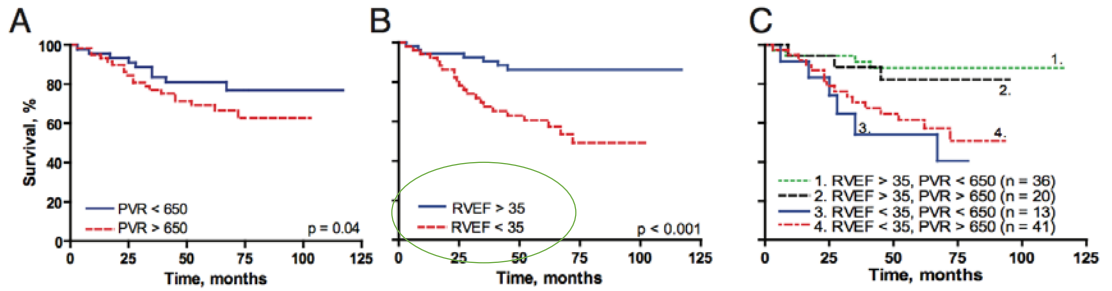
Vol. 58, No. 24, 2011
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2011.06.068

Progressive Right Ventricular Dysfunction in Patients With Pulmonary Arterial Hypertension Responding to Therapy

Mariëlle C. van de Veerdonk, MD,* Taco Kind, MD,* J. Tim Marcus, PhD,† Gert-Jan Mauritz, MSc,*

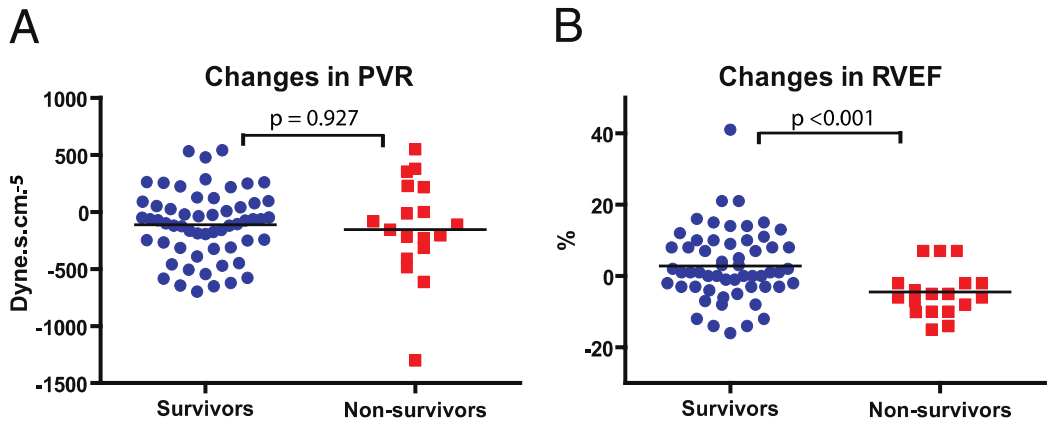


Variable	Baseline	Follow-Up	P value
6MWT			
Distance, m	421 ± 117	425 ± 139	0.727
Hemodynamics			
mPAP, mm Hg	50 ± 16	47 ± 16	0.176
mRAP, mm Hg	7 ± 4	7 ± 5	0.557
PCWP, mm Hg	7 ± 4	7 ± 4	0.966
PVR, dyne·s·cm^{-5}	772 ± 384	660 ± 378	0.003
CO, l/min	4.9 ± 1.3	5.4 ± 2.4	0.032
Cardiac index, l/min/m^2	2.7 ± 0.7	3.0 ± 1.2	0.026
Heart rate, beats/min	85 ± 16	83 ± 12	0.182
SvO_2, %	66 ± 8	65 ± 10	0.641
CMR measurements			
RVEDVI, ml/m^2	72 ± 24	76 ± 32	0.099
RVESVI, ml/m^2	48 ± 22	51 ± 30	0.167
RVEF, %	35 ± 10	36 ± 13	0.413



re 2 Survival Rates of Patients With PAH Stratified According to PVR and RVEF at Baseline

- El cambio en la FEVD se asoció con la supervivencia mientras que el cambio en las RVP no lo hizo.
- Las RVP disminuyeron significativamente a los 12 meses de tratamiento vasodilatador. Pese a ello, un 25% de los pacientes desarrolló deterioro de la FEVD y peor pronóstico.



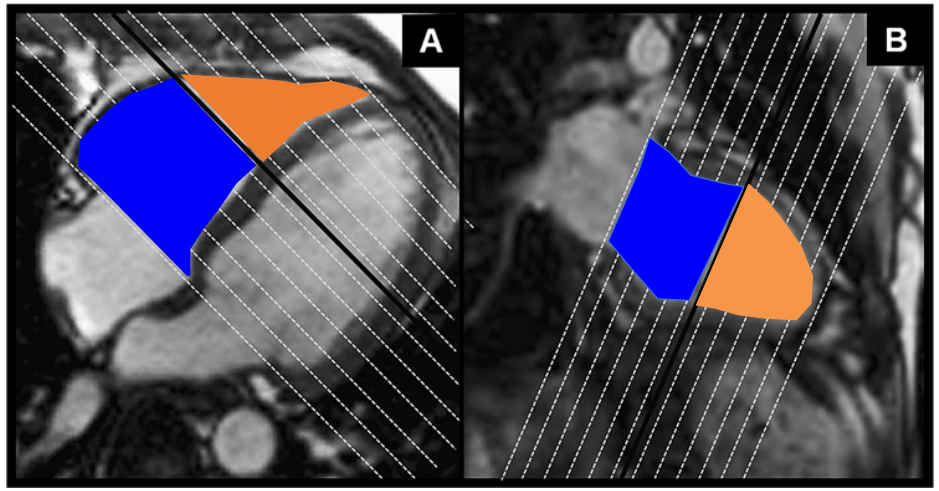
Evaluación de la motilidad segmentaria del VD

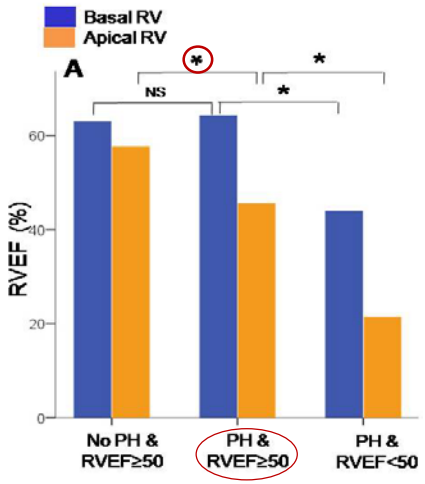
HEART

Apical right ventricular dysfunction in patients with pulmonary hypertension demonstrated with magnetic resonance

Leticia Fernandez-Friera, Ana Garcia-Alvarez, Gabriela Guzman, et al.

Heart 2011 97: 1250-1256 originally published online June 14, 2011
doi: 10.1136/hrt.2010.216101

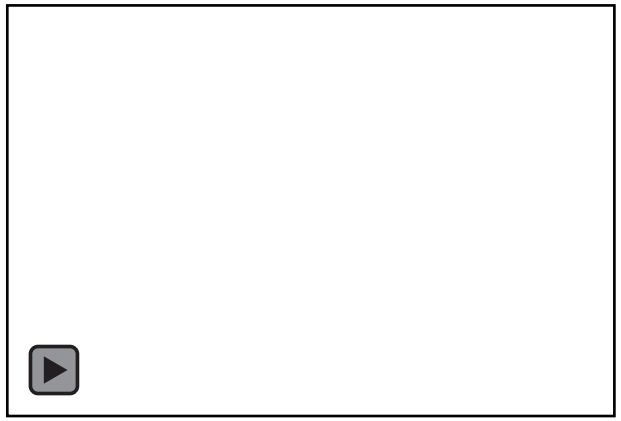




CrossMark

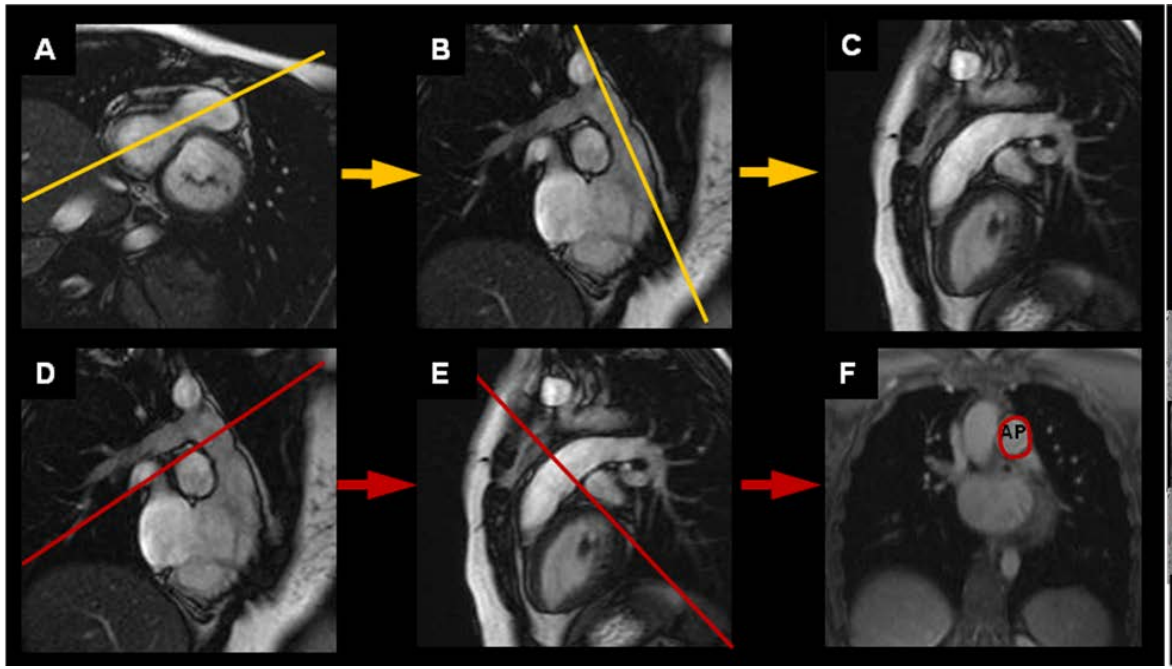
Characterization and clinical significance of right ventricular mechanics in pulmonary hypertension evaluated with cardiovascular magnetic resonance feature tracking

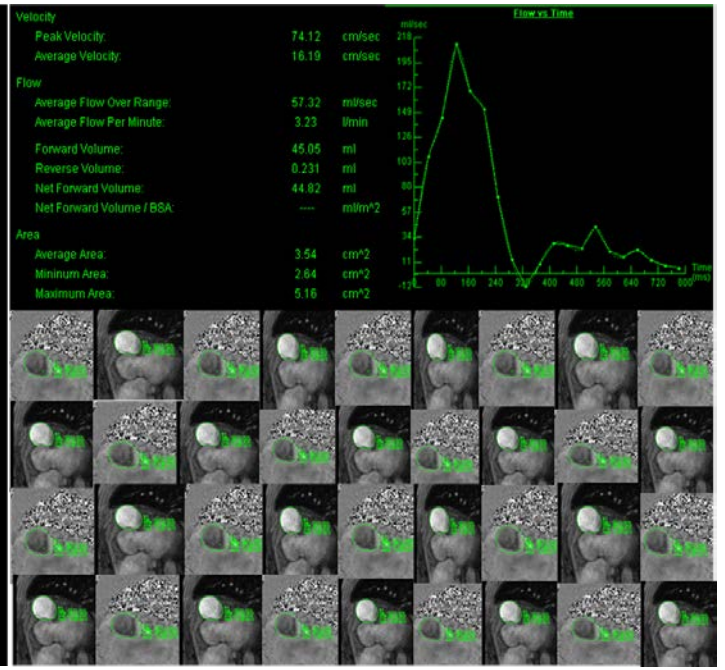
Maria Eduarda Menezes de Siqueira[1,2], Eduardo Pozo[1,3], Veronica R. Fernandes[1], Partho P. Sengupta[1], Karen Modesto[1], Sushilkumar Satish Gupta[1], Cayetana Barbeito-Caamaño[1,4], Jagat Narula[1], Valentin Fuster[1], Adriano Caixeta[2] and Javier Sanz[1,5*]



- N=110 pts
- Seguimiento 2 años, 78 eventos (muerte, TXP o ↓CF).
- El strain circunferencial global fue predictor independiente.

Evaluación de la anatomía y flujo de la AP





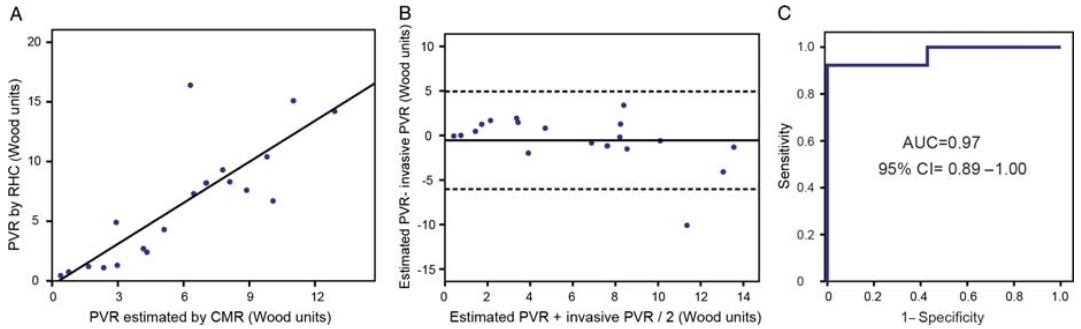
- ✓ Área y rigidez de la AP.
- ✓ Velocidad media AP.
- ✓ Gasto cardiaco.
- ✓ Estimación no invasiva de RVP.
- ✓ Acoplamiento ventrículo-arterial.

Estimación no invasiva de RVP con RMC:

PVR = 19.38 – [4.62 x Ln Vmedia AP] – [0.08 x FEVD]

- N=100 pts (80/20) con HP.

García-Alvarez A et al. Eur Heart J 2011



Monitorización no invasiva de los cambios en RVP y test vasodilatador pulmonar:

- Estudio experimental.

García-Álvarez A et al. JACC 2013

Embolización aguda **HP crónica** **Test vasodilatador**

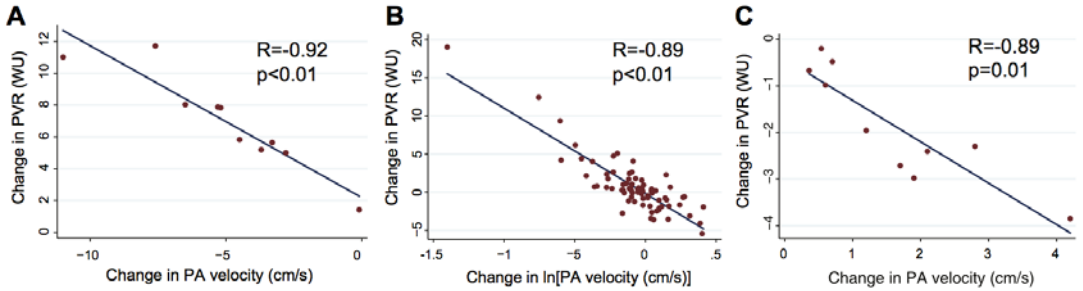


Figure 3 Correlation Between Changes in PVR and Changes in Average PA Velocity in the 3 Different Conditions

Valor pronóstico RVP por RMC en IC crónica:

- N=132 pts con IC (FEVI media 35%), seguimiento 10 m.
- 37 ingresos IC, 9 exitus.

Fabregat-Andrés O et al. EHJCV Imaging 2014

Otras secuencias de RMC en HP:

Área y rigidez AP

Noninvasively Assessed Pulmonary Artery Stiffness Predicts Mortality in Pulmonary Arterial Hypertension*

C. Tji-Joong Gan, MSc; Jan-Willem Lankhaar, MSc; Nico Westerhof, PhD; J. Tim Marcus, PhD; Annemarie Becker, MD, PhD; Jos W. R. Twisk, PhD; Anco Boonstra, MD, PhD; Pieter E. Postmus, MD, PhD, FCCP; and Anton Vonk-Noordegraaf, MD, PhD, FCCP

N=70 pts HAP, 18 exitus.
Pulsatilidad (cambio relativo de área de la AP) es predictor de mortalidad.

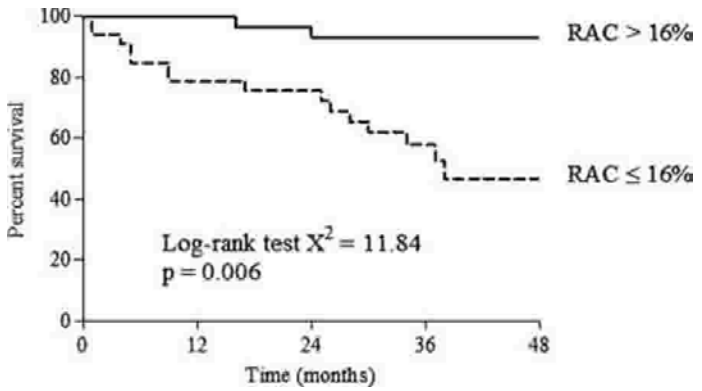
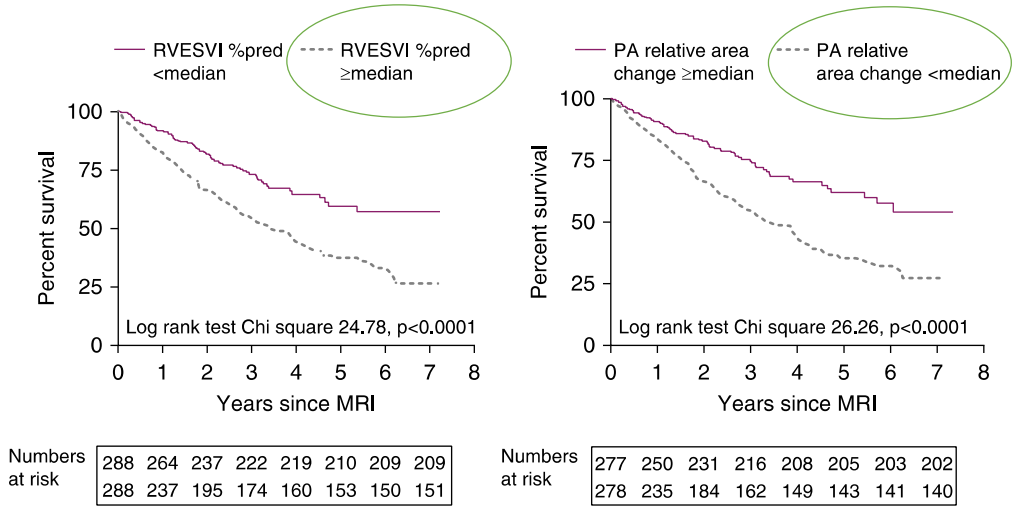


FIGURE 4. Kaplan-Meier survival curve for PAH patients with ΔA/A above and below the median value.

Magnetic Resonance Imaging in the Prognostic Evaluation of Patients with Pulmonary Arterial Hypertension

Andrew J. Swift[1,2], Dave Capener[1], Chris Johns[1], Neil Hamilton[3], Alex Rothman[1,2], Charlie Elliot[3], Robin Condliffe[3], Athanasios Charalampopoulos[3], Smitha Rajaram[4], Allan Lawrie[1,2], Michael J. Campbell[5], Jim M. Wild[1,2], and David G. Kiely[1,2,3]

N=576 HAP pts con HAP procedentes del registro ASPIRE.
Seguimiento medio 42 meses, 221 exitus.
Predictores pronósticos independientes: edad>50 años, CTD, monoterapia vs. combinación, SvO2, RVESV & PA RAC.



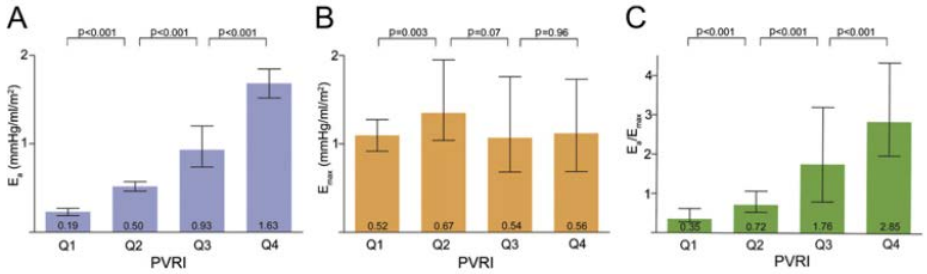
Acoplamiento ventrículo-arterial por RMC

HEART

Right ventriculo-arterial coupling in pulmonary hypertension: a magnetic resonance study

Javier Sanz, Ana García-Alvarez, Leticia Fernández-Friera, et al.

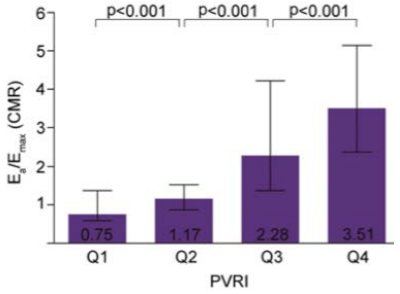
Heart published online September 13, 2011
doi: 10.1136/heartjnl-2011-300462

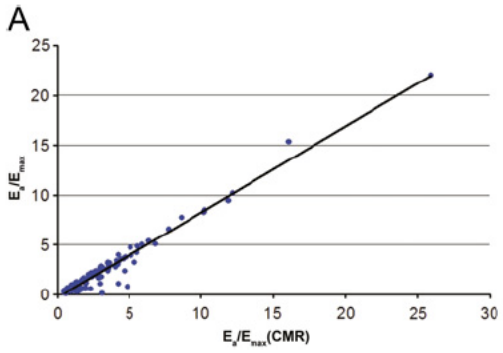


Ea= (mPAP – PCWP)/SV

Emax= mPAP/ESV

Ea/Emax





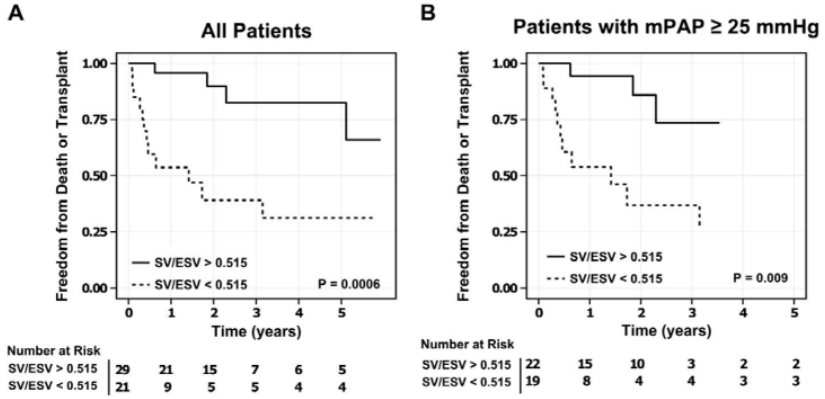
Ea/Emax (CMR)= ESV/SV

Right Ventricular-Pulmonary Arterial Coupling Predicts Outcome in Patients Referred for Pulmonary Hypertension

Rebecca R. Vanderpool, PhD[1], Michael R Pinsky, MD, CM, Dr hc[2,3,4], Robert Naeije, MD, PhD[5], Christopher Deible, MD, PhD[6], Vijaya Kosaraju, BS[7], Cheryl Bunner, RN[2], Michael A. Mathier, MD[2], Joan Lacomis, MD[6], Hunter C. Champion, MD, PhD[2,8,1,*], and Marc A. Simon, MS, MD[1,2,3,*]

Heart 2015

N=50 pts, 16 eventos (exitus o TXP).

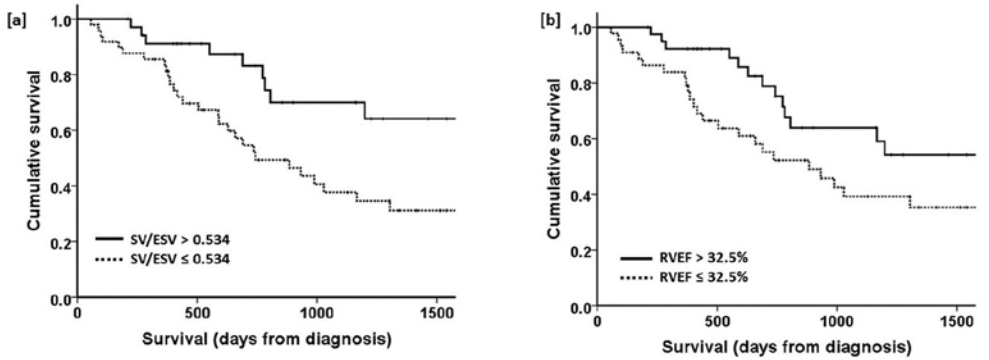


Imaging right ventricular function to predict outcome in pulmonary arterial hypertension

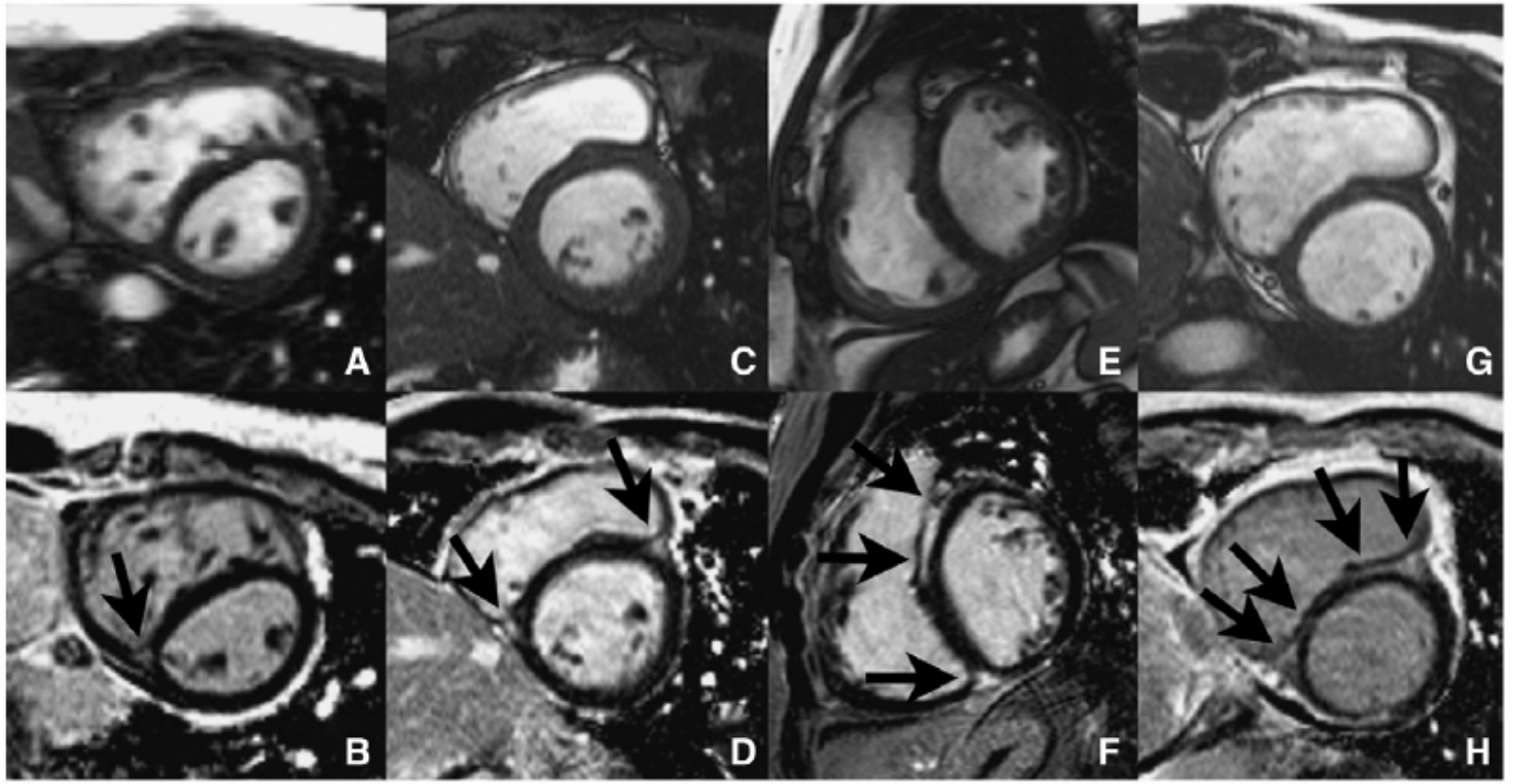
Melanie J. Brewis [a,*], Alessandro Bellofiore [b], Rebecca R. Vanderpool [c], Naomi C. Chesler [d], Ma
Robert Naeije [e], Andrew J. Peacock [a]

Int J Cardiol 2016

N=140 PAH pts, 61 exitus.



Caracterización tisular: Realce tardío



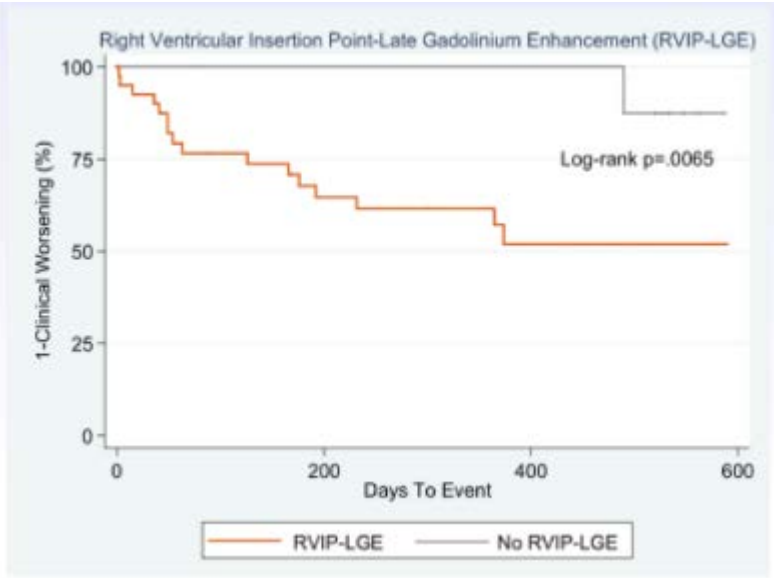
- ✓ Prevalente: ≈90%[1,2] en punto de inserción del VD y septo.
- ✓ Asociado con la severidad de la HP[2].
- ✓ Probable factor pronóstico[3].

1. Blyth. Eur Heart J 2005; 2. Sanz J. Am J Cardiol 2007; 3. Freed B. J Cardiovasc Magn Reson 2012.

Valor pronóstico del realce

Late gadolinium enhancement cardiovascular magnetic resonance predicts clinical worsening in patients with pulmonary hypertension

Benjamin H Freed[1], Mardi Gomberg-Maitland[1], Sonal Chandra[1], Victor Mor-Avi[1], Stuart Rich[1], Stephen L Archer[1], E Bruce Jamison Jr[2], Roberto M Lang[1,2] and Amit R Patel[1,2*]



58 pts con HP, 69% con LGE, 76% HAP.
19 eventos (10 m): exitus, descomp IC, prostaciclinas o trasplante.
RVIP-LGE predictor univariante de empeoramiento clínico pero no significativo en AA multivariante (mPAP, METs, FEVD).

LGE Patterns in Pulmonary Hypertension Do Not Impact Overall Mortality

Andrew J. Swift, PhD,*† Smitha Rajaram, MD,* Dave Capener, MSc,* Charlie Elliot, MBChB,‡ Robin Condliffe, MD,‡ Jim M. Wild, PhD,* David G. Kiely, MD‡

162 pts con HP (RMC y CCD en 48 hrs), 83% con LGE.
39 exitus (3 años).

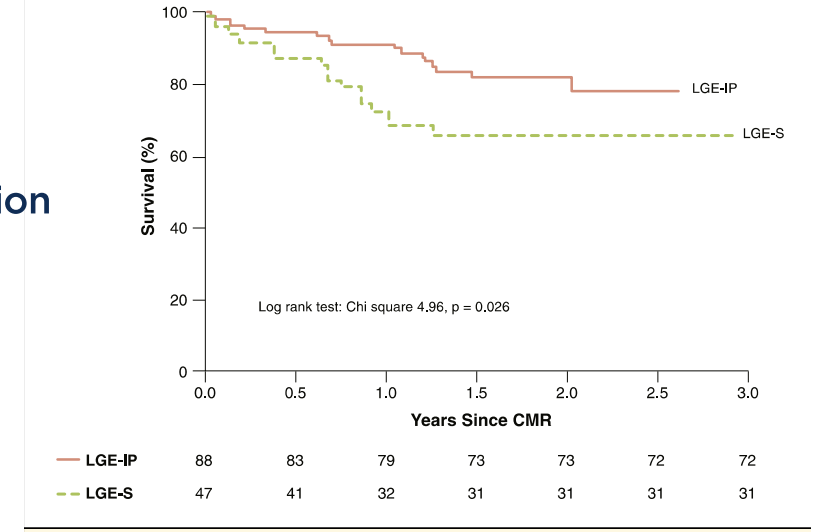


FIGURE 2 Kaplan-Meier Plot Analysis: Outcome Comparison for Patients With LGE-IP Versus LGE-S

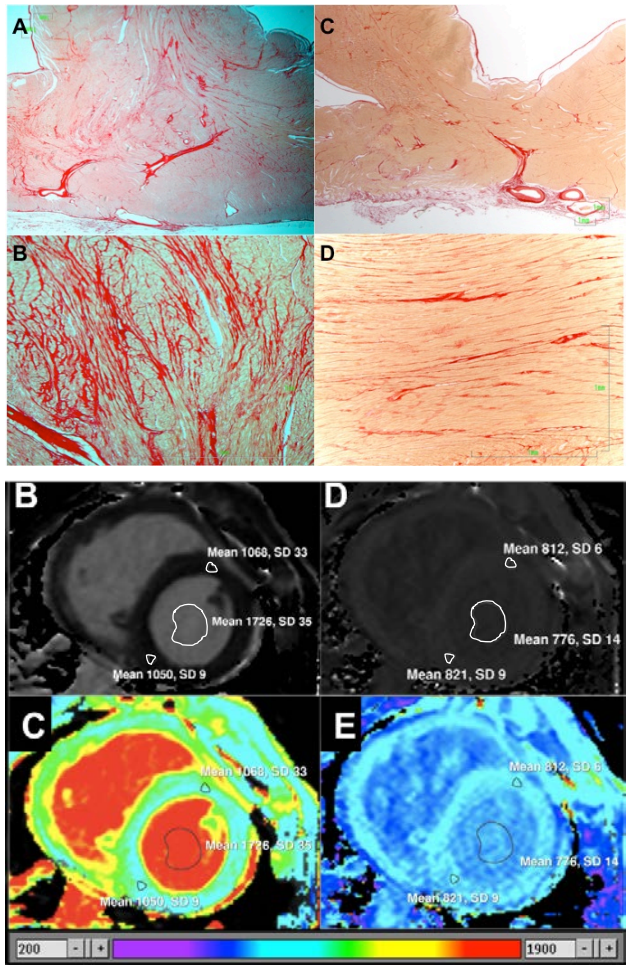
TABLE 4 Demographic, Right Heart Catheter, and CMR Metrics as Predictors of Adverse Outcome Using Cox Proportional Hazards Regression Analysis

Overall Mortality	Univariate Hazard Ratio (95% CI)	p Value	Multivariate Hazard Ratio (95% CI)	p Value
Demographics				
Age, yrs	1.017 (0.993-1.042)	0.164		
Sex, female %	0.334 (0.167-0.666)	0.002	0.414 (0.190-0.906)	0.027
WHO functional class	2.253 (0.795-6.387)	0.126		
Invasive catheter measurements				
sPAP, mm Hg	0.994 (0.980-1.008)	0.396		
dPAP, mm Hg	0.998 (0.969-1.031)	0.988		
mPAP, mm Hg	0.993 (0.969-1.018)	0.599		
mRAP, mm Hg	1.069 (1.008-1.135)	0.027	1.060 (0.983-1.129)	0.093
PCWP, mm Hg	1.005 (0.946-1.068)	0.867		
Svo_2, %	0.954 (0.917-0.993)	0.021	0.987 (0.936-1.042)	0.645
CI, $l.min^{-1}.m^{-2}$	0.773 (0.489-1.221)	0.269		
PVR, $dyn.s.cm^{-5}$	1.000 (1.000-1.001)	0.298		
MR indexes				
RVEDVI, ml/m^2	1.004 (0.996-1.012)	0.367		
RVESVI, ml/m^2	1.009 (1.000-1.017)	0.045	0.997 (0.982-1.012)	0.686
RVEF, %	0.970 (0.944-0.999)	0.034	0.987 (0.956-1.019)	0.413
RVSVI, ml/m^2	0.972 (0.942-1.003)	0.073		
LVEDVI, ml/m^2	0.995 (0.964-1.028)	0.995		
LVESVI, ml/m^2	1.013 (0.947-1.062)	0.577		
LVEF, %	0.983 (0.950-1.016)	0.308		
LVSVI, ml/m^2	0.981 (0.940-1.026)	0.412		
VMI, ratio	0.606 (0.196-1.872)	0.384		
LGE present or absent	1.138 (0.474-2.728)	0.773		
LGE-S	2.139 (1.115-4.103)	0.022	1.598 (0.722-3.540)	0.248

T1-mapping

HP crónica

Animal control

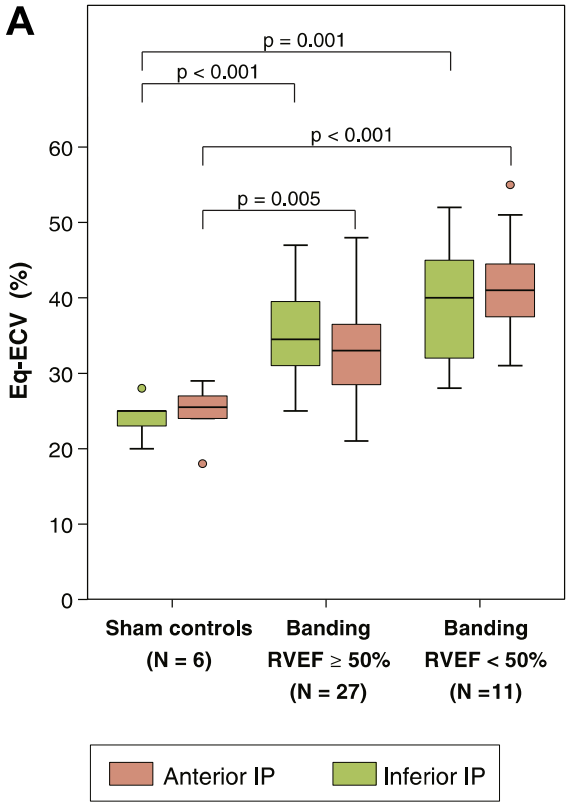


iCONCEPTS

CONCEPTS ON THE VERGE OF TRANSLATION

Association of Myocardial T1-Mapping CMR With Hemodynamics and RV Performance in Pulmonary Hypertension

Ana García-Álvarez, MD, PhD,*†‡ Inés García-Lunar, MD,*†§ Daniel Pereda, MD,*†‡
Rodrigo Fernández-Jimenez, MD,*†‖ Javier Sánchez-González, PhD,*†¶ Jesús G. Mirelis, MD, PhD,*†#
Mario Nuño-Ayala, PhD,*† Damian Sánchez-Quintana, MD,** Leticia Fernández-Friera, MD, PhD,*†††
Jose M. García-Ruiz, MD,*†‡‡ Gonzalo Pizarro, MD,*†§ Jaume Agüero, MD,*† Paula Campelos, MD,‡
Manuel Castellá, MD, PhD,‡ Manel Sabaté, MD, PhD,‡ Valentin Fuster, MD, PhD,†§§ Javier Sanz, MD,§§
Borja Ibañez, MD, PhD*†‖



JACC Cardiovasc Imaging 2015

Increased native T1-values at the interventricular insertion regions in precapillary pulmonary hypertension

Onno A. Spruijt[1] · Loek Vissers[1] · Harm-Jan Bogaard[1] · Mark B. M. Hofman[2] · Anton Vonk-Noordegraaf[1] · J. Tim Marcus[2]

Native T1 mapping and extracellular volume fraction measurement for assessment of right ventricular insertion point and septal fibrosis in chronic thromboembolic pulmonary hypertension

Fritz C. Roller[1] · Christoph Wiedenroth[2] · Andreas Breithecker[1] · Christoph Liebetrau[3] · Eckhard Mayer[2] · Christian Schneider[1] · Andreas Rolf[3] · Christian Hamm[3,4] · Gabriele A. Krombach[1]

Left Ventricular Myocardial Fibrosis, Atrophy, and Impaired Contractility in Patients With Pulmonary Arterial Hypertension and a Preserved Left Ventricular Function

A Cardiac Magnetic Resonance Study

Rami Homsi, MD, Julian A. Luetkens, MD,* Dirk Skowasch, MD,† Carmen Pizarro, MD,† Alois M. Sprinkart, MSc,* Juergen Gieseke, MSc,*‡ Julia Meyer zur Heide gen. Meyer-Arend, MD,† Hans H. Schild, MD,* and Claas P. Naehle, MD**

European Radiology
March 2019, Volume 29, Issue 3, pp 1565–1573 | Cite as

Correlation of native T1 mapping with right ventricular function and pulmonary haemodynamics in patients with chronic thromboembolic pulmonary hypertension before and after balloon pulmonary angioplasty

Authors | Authors and affiliations

F. C. Roller, S. Kriechbaum, A. Breithecker, C. Liebetrau, M. Haas, C. Schneider, A. Rolf, S. Guth, E. Mayer, C. Hamm, G. A. Krombach, C. B. Wiedenroth

Valor pronóstico T1/ECV en HP

RESEARCH

Diagnostic and prognostic significance of cardiovascular magnetic resonance native myocardial T1 mapping in patients with pulmonary hypertension

Laura C. Saunders[1], Chris S. Johns[1], Neil J. Stewart[1,2], Charlotte J. E. Oram[1], David A. Capener[1], Valentina O. Puntmann[3], Charlie A. Elliot[4], Robin C. Condliffe[4], David G. Kiely[4,5], Martin J. Graves[6], Jim M. Wild[1,5*] and Andy J. Swift[1,5]

- 490 pts con RMC 1,5 T realizada en 1 centro. 369 PH (multifactorial, 223 PAH), 39 LHD, 82 no PH, 25 controles.
- Análisis de T1 nativo (MOLLI).
- Seguimiento clínico 29 meses (59 exitus).

Table 6 Cox linear regression analysis for RV insertion point T1 in PAH. All variables have been normalised

	Univariate Hazard Ratio	Univariate 95% confidence interval	Univariate P Value
Age	1.938	1.342–2.798	< 0.001**
Sex	0.765	0.573–1.021	0.077
Septal T1	0.909	0.661–1.249	0.552
RV insertion point T1	1.067	0.778–1.464	0.688
LV free wall T1	1.195	0.879–1.624	0.258
$\Delta T1_{RS}$	1.205	0.888–1.634	0.237
RVEDVI	1.642	1.330–2.027	< 0.001**
RVESVI	1.804	1.453–2.240	< 0.001**
RVEF	0.506	0.372–0.690	< 0.001**
Systolic septal angle	1.454	1.093–1.934	0.011**
Diastolic septal angle	1.485	1.099–2.008	0.011**
RV mass Index	1.341	1.091–1.649	0.018**

Legend: *RVEDVI* right ventricular end diastolic volume index, *RVESVI* right ventricular end systolic volume index, *RVEF* right ventricular ejection fraction

Native T1 time of right ventricular insertion points by cardiac magnetic resonance: relation with invasive haemodynamics and outcome in heart failure with preserved ejection fraction

Christian Nitsche, Andreas A Kammerlander, Christina Binder, Franz Duca, Stefan Aschauer, Matthias Koschutnik, Amir Snidat, Dietrich Beitzke, Christian Loewe, Diana Bonderman ... Show more

European Heart Journal - Cardiovascular Imaging, jez221, https://doi-

- 167 pts.
- Seguimiento 43 meses (18% fallecieron).
- T1 nativo a nivel del punto de inserción posterior predictor independiente.

Revisión sistemática

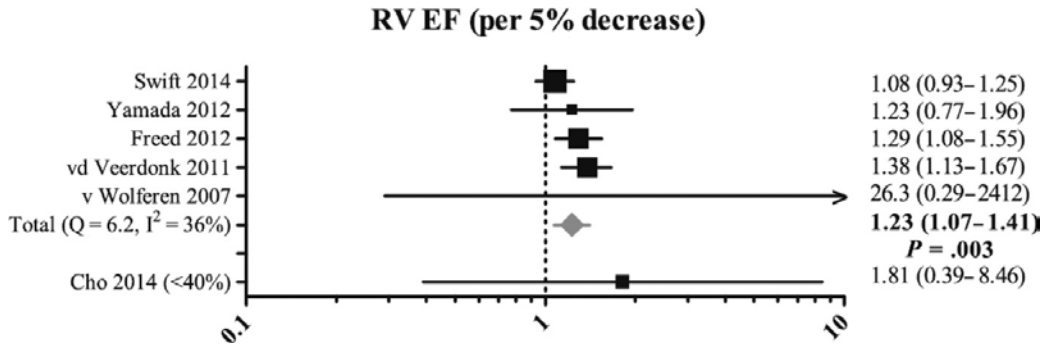
Eur Radiol (2016) 26:3771–3780
DOI 10.1007/s00330-016-4217-6

CARDIAC

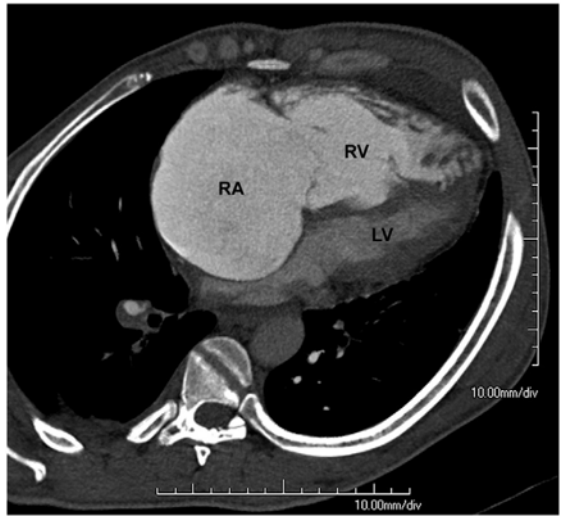
Cardiac magnetic resonance findings predicting mortality in patients with pulmonary arterial hypertension: a systematic review and meta-analysis

Vivan J. M. Baggen[1,2] · Tim Leiner[3] · Marco C. Post[1] · Arie P. van Dijk[1] · Jolien W. Roos-Hesselink[2] · Eric Boersma[2,4] · Jesse Habets[3] · Gertjan Tj. Sieswerda[1]

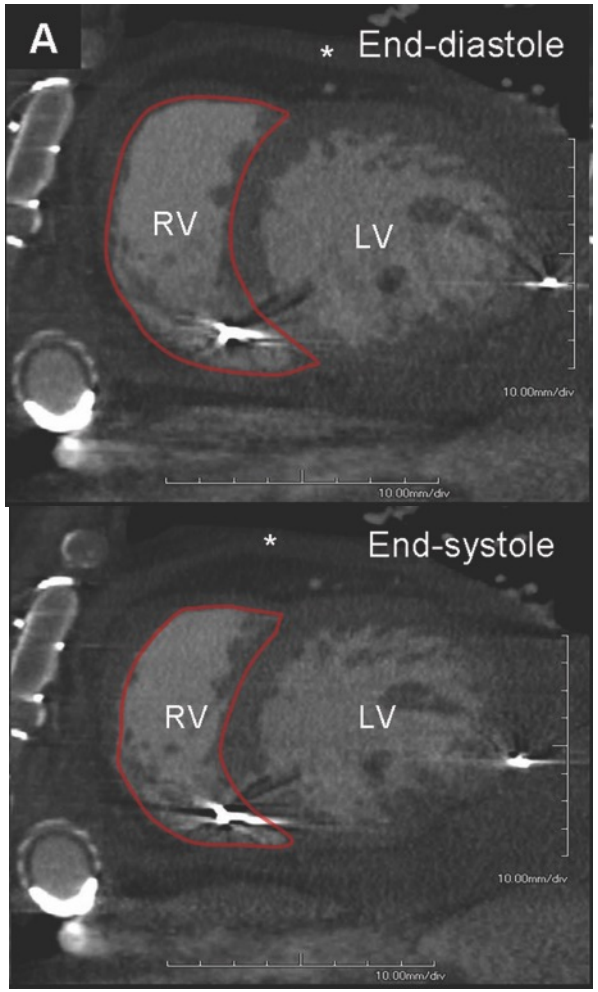
- Metaanálisis de 8 estudios (N=539 pacientes) con HAP.
- Se estudió el valor pronóstico de 9 variables de RMC (volumen, función, flujo, LGE).
- Predictor más potente de mortalidad: FEVD.
- VTDVDi, VTSVDi, VTDVIi, SV index (Qflow) asociación con mortalidad, no así la masa biventricular.
- No suficientes datos para el resto de variables (PA pulsatility, LGE…).



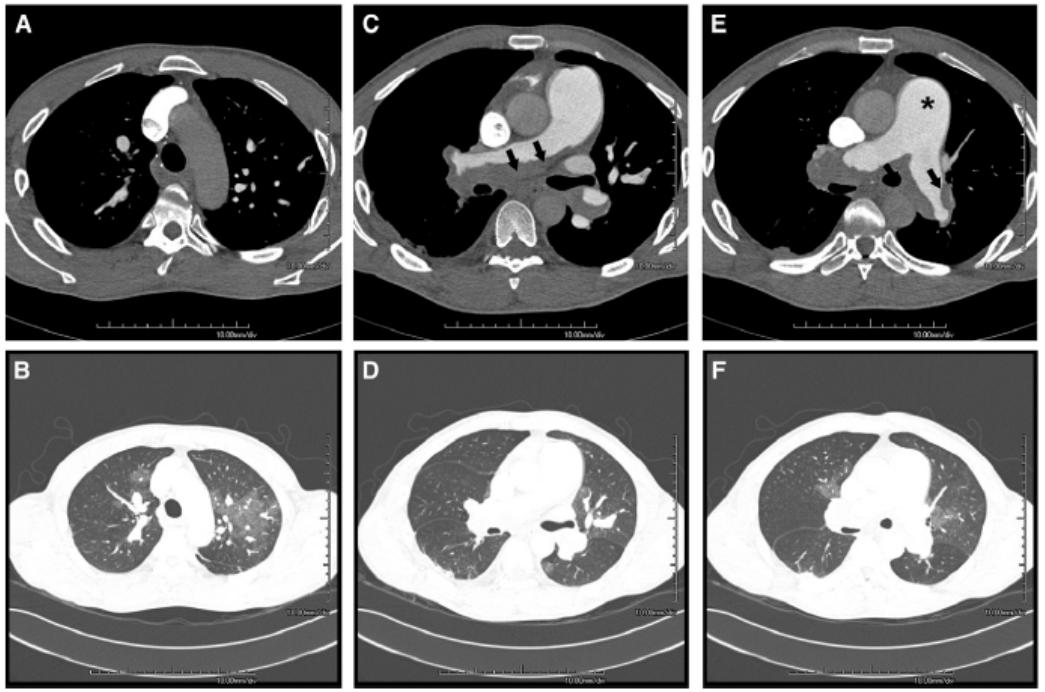
TAC



Dimensiones de AD y VD



Función ventricular derecha



Ratio AP: aorta; **tromboembolismo**; fibrosis pulmonar

✓ **Aporta información fundamentalmente anatómica. Muy útil para identificar TEP crónico.**

García-Álvarez et al. Heart & Lung transp 2011

PET

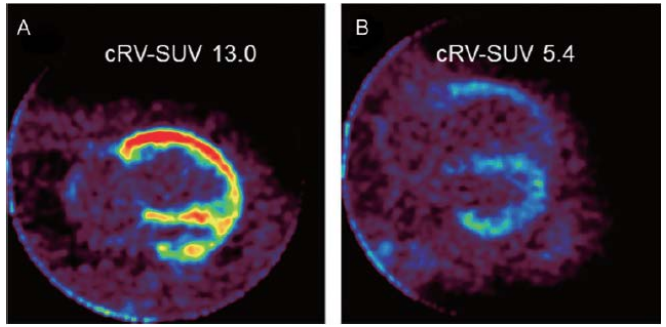
European Heart Journal – Cardiovascular Imaging (2014) **15**, 666–672
doi:10.1093/ehjci/jet276

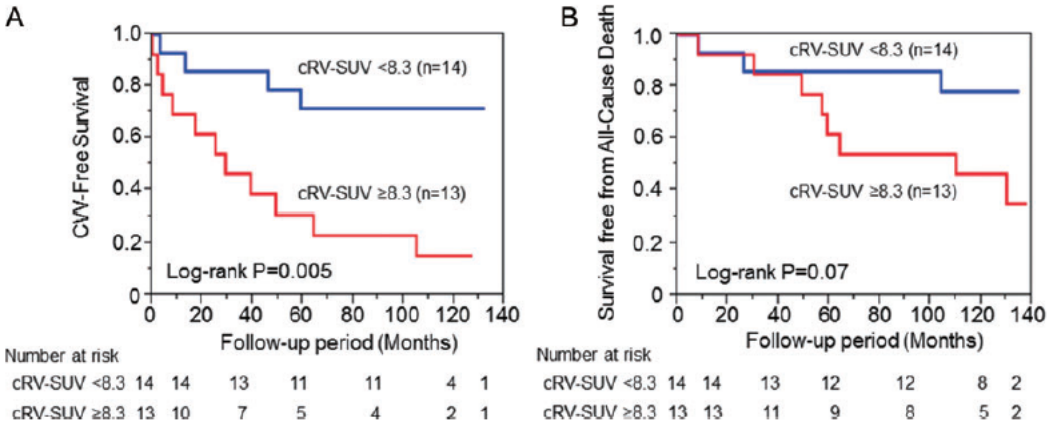
Enhanced [^{18}F]fluorodeoxyglucose accumulation in the right ventricular free wall predicts long-term prognosis of patients with pulmonary hypertension: a preliminary observational study

Shunsuke Tatebe[1], Yoshihiro Fukumoto[1]*, Minako Oikawa-Wakayama[2],

N=27

Empeoramiento clínico o muerte.





Conclusiones:

- Desde un punto de vista pronóstico tienen más impacto las medidas que reflejan el grado de función VD y el acoplamiento ventrículo-arterial, que la propia hemodinámica pulmonar.
- Desde el punto de vista hemodinámico, la PAPi posee relevancia creciente y valor pronóstico.
- La ecocardiografía es una técnica esencial por su disponibilidad, el strain longitudinal y el acoplamiento medido como TAPSE/PAPs parecen tener mayor impacto pronóstico.
- La RMC permite cuantificar la FEVD con precisión y hasta ahora es la variable con mayor impacto pronóstico (probablemente igualada con el acoplamiento, medido como VS/VTS). Otras medidas como las características elásticas de la AP o la fibrosis difusa pueden aportar información relevante en estadios más precoces.
- La tomografía es una buena alternativa a la RMC en pacientes con dispositivos (LVAD).
- Otros métodos como el PET, omics y genética ayudarán a entender la adaptación del VD a la HP, con potencial impacto en el pronóstico o tratamiento personalizado.

Gracias!

Covariate	Univariable Analysis OR (95% CI)	*P* Value
Demographic and clinical characteristics		
Age (per 1-y increase)	1.005 (0.996–1.013)	0.27
Female sex	1.032 (0.780–1.366)	0.83
Body surface area (per 1-m^2 unit increase)	1.501 (0.933–2.414)	0.09
Body mass index (per 1-kg/m^2 unit increase)	1.018 (0.997–1.039)	0.10
Race (white vs others)	3.785 (2.829- 5.064)	<0.001
Heart failure origin (nonischemic vs ischemic)	0.986 (0.787–1.236)	0.91
NYHA functional class (IV vs III)	1.677 (1.354–2.078)	<0.001
INTERMACS (1–3 vs 4–7)	2.969 (2.218–3.974)	<0.001
Blood type O (yes vs no)	1.153 (0.926–1.435)	0.20
Diabetes mellitus (yes vs no)	1.142 (0.505–3.055)	0.64
History of CVA (yes vs no)	0.966 (0.665–1.404)	0.86
Symptomatic PVD (yes vs no)	1.173 (0.742–1.856)	0.50
History of cardiac arrest (yes vs no)	2.240 (1.494–3.357)	<0.001
Use of mechanical ventilation (yes vs no)	2.457 (1.803–3.348)	<0.001
Use of feeding tube (yes vs no)	3.485 (2.382–5.099)	<0.001
ICD implantation (yes vs no)	1.054 (0.848–1.310)	0.63
COPD (yes vs no)	0.757 (0.529–1.083)	0.13
Prior major MI (yes vs no)	1.536 (1.536- 2.076)	0.005
Prior cardiac surgery (yes vs no)	1.501 (1.102- 2.045)	0.01
Renal replacement therapy (yes vs no)	4.191 (2.427–7.237)	<0.001
Ultrafiltration (yes vs no)	2.332 (1.497–3.635)	<0.001
Intra-aortic balloon pump (yes vs no)	1.983 (1.450–2.712)	<0.001
VA-ECMO (yes vs no)	3.565 (2.596–4.896)	<0.001
Medication use		
Use of vasopressors	3.026 (2.373–3.858)	<0.001
≥3 Intravenous inotropes	2.601 (1.953–3.466)	<0.001
Amiodarone	1.787 (1.415–2.257)	<0.001
ACE inhibitors	0.772 (0.611–0.975)	0.03
β-Blockers	0.521 (0.410–0.662)	<0.001
Aldosterone antagonists	0.611 (0.477–0.783)	<0.001
Loop diuretics	1.529 (1.067–2.193)	0.02
Anticoagulant therapy	3.040 (2.284–4.045)	<0.001

Covariate	Univariable Analysis OR (95%CI)	*P* value
Laboratory characteristics		
Sodium	1.010 (1.002–1.018)	0.01
Potassium	1.237 (1.075–1.425)	0.003
BUN	1.004 (1.002–1.007)	0.001
Creatinine (per 1-unit increase)	1.407 (1.213–1.632)	<0.001
Creatinine >2.3 mg/dL (75%)	2.373 (1.662–3.389)	<0.001
AST >37 U/L	2.091 (1.661–2.633)	<0.001
ALT >72 IU/L	2.400 (1.736–3.319)	<0.001
LDH (>445 vs ≤445 U/L)	1.554 (1.173–2.058)	0.002
Total bilirubin >2 mg/dL	1.620 (1.260–2.082)	<0.001
Albumin (<3.3 vs ≥3.3 g/dL)	1.107 (0.809–1.515)	0.52
WBCs	1.050 (1.026–1.074)	<0.001
Hemoglobin ≤10 g/dL	1.628 (1.281–2.070)	<0.001
Platelets	0.996 (0.996–0.998)	<0.001
HCO_3 (per 1-mEq/dL increase)	0.996 (0.963–1.030)	0.80

Hemodynamic characteristics		
Nonsinus vs sinus rhythm	1.202 (0.957–1.508)	0.11
Heart rate (≥96 vs <96 bpm)	1.445 (1.141–1.832)	0.002
Systolic blood pressure (≤85 vs >85 mm Hg)	1.623 (1.202–2.190)	0.002
Diastolic blood pressure (≤52 vs >52 mm Hg)	1.629 (1.199–2.213)	0.002
Cardiac index (≤1.2 vs >1.2 L/min)	0.817 (0.482–1.387)	0.46
PAP, systolic (≥53 vs <53 mm Hg)	1.220 (0.919–1.620)	0.17
PAP, diastolic (≥27 vs <27 mm Hg)	0.818 (0.617–1.085)	0.16
PAP, mean (≥35 vs <35 mm Hg)	0.967 (0.730–1.282)	0.82
RA pressure (≥11 vs <11 mm Hg)	1.729 (1.279–2.338)	0.001
PCWP (≥12 vs <12 mm Hg)	1.086 (0.649–1.819)	0.75
SVR (≥1488 vs <1488 mm Hg)	0.712 (0.479–1.059)	0.09
TPG (≥12 vs <12 mm Hg)	1.043 (0.758–1.436)	0.80
PVR (≥3.3 vs <3.3 mm Hg)	0.163 (0.027–0.983)	0.05
PAPI (≤1.6 vs >1.6)	2.175 (1.584–2.988)	<0.001
RVSWI (≤4.6 vs >4.6 g/m^2 per beat)	1.481 (1.051–2.086)	0.03
RA/PCWP (>0.54 vs ≤0.54)	2.075 (1.383–3.112)	<0.001

Valor pronóstico de las medidas ecocardiográficas de función del VD en HP

HFpEF					
Lam et al., *J Am Coll Cardiol*, 2009	LVEF ≥50% Framingham criteria	244	Prospective	Echo estimated RVSP >35 mm Hg	Study showing the prognostic value of PH in HFpEF. RVSP ≥48 mm Hg had worse all-cause mortality than RVSP <48 mm Hg ($p < 0.01$) during 2.4 ± 1.2 yrs follow-up.
Aschauer et al., *Eur J Heart Fail*, 2016	LVEF >50% Signs or symptoms of heart failure NT-proBNP >220 pg/ml LV diastolic dysfunction	171	Prospective	RVEF RVFAC TAPSE	RV systolic dysfunction (RVEF <45% using CMR) was independently associated with event-free survival (HR: 4.90 [95% CI: 2.46-9.75]). RVEF was superior to RVFAC and TAPSE for prediction of cardiac events.
Freed et al., *Circ Cardiovasc Imaging*, 2016	LVEF ≥50% Framingham criteria	308	Prospective	RVFAC <35% TAPSE <16 mm RVLS >-20%	RV strain was associated with outcome (univariate HR: 1.30 [95% CI: 1.07-1.58]). Using multivariate analysis, RV strain was not retained, whereas LA strain and LA stiffness were.
Tampakakis et al., *Circ Heart Fail, 2018*	HFrEF or HFpEF with pulmonary hypertension	1,036	Retrospective	Pulmonary arterial compliance, elastance, resistance	Pulmonary arterial compliance and elastance were more strongly associated with outcome than resistance or transpulmonary gradient
HFrEF					
Ghio et al., *Eur J Heart Fail*, 2013	LVEF <45%	658	Prospective	SPAP ≥40 mm Hg TAPSE ≤14 mm	SPAP ≥40 mm Hg and TAPSE ≤14 mm were associated with worst outcome (death, urgent heart transplant, ventricular fibrillation). Their combination improved risk stratification.
Moneghetti et al., *Eur Heart J Cardiovasc Imaging*, 2017	Dilated cardiomyopathy	208	Retrospective	RA volume index	RA volume index is complementary to well-validated heart failure risk scores, which highlights the importance of exercise performance in dilated cardiomyopathy.
Carluccio et al., *Circ Cardiovasc Imaging*, 2018	HFrEF with TAPSE >16 mm	200	Prospective	RVLS	RVLS >-15.3% was associated with outcomes and reclassified patients with TAPSE >16 mm.

European Journal of Heart Failure (2016) 18, 564–572
doi:10.1002/ejhf.504

RESEARCH ARTICLE

Prognostic incremental role of right ventricular function in acute decompensation of advanced chronic heart failure

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RVCPI= TAPSE x gradiente IT