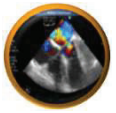
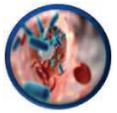
DIU TUSAR

Bordeaux – Mardi 16 décembre 2025





Coeur pulmonaire aigu

Philippe Vignon

Réanimation Polyvalente
Inserm CIC 1435
CHU Limoges

Définition

- Syndrome lié à une élévation brutale de la post-charge du ventricule droit secondaire à un obstacle de la circulation pulmonaire situé entre l'origine de l'artère pulmonaire et les capillaires pulmonaires
- Principales causes en réanimation :
  - ✓ Embolie pulmonaire (EP) massive
  - ✓ SDRA (ventilation mécanique)
  - ✓ Choc septique.

Définition

EUROPEAN RESPIRATORY JOURNAL
ERS OFFICIAL DOCUMENTS
M. HUMBERT ET AL.

2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension

Developed by the task force for the diagnosis and treatment of pulmonary hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS)

Endorsed by the International Society for Heart and Lung Transplantation (ISHLT) and the European Reference Network on rare respiratory diseases (ERN-LUNG)

Marc Humbert[1,2], Gabor Kovacs[3,4], Marius M. Hoeper[5,6], Roberto Badagliacca[7,8], Rolf M.F. Berger[9], Margarita Brida[10,11], Jørn Carlsen[12,13], Andrew J.S. Coats[14,15], Pilar Escribano-Subias[16,17,18], Pisana Ferrari[19,20], Diogenes S. Ferreira[21], Hossein Ardeschir Ghofrani[22,23,24], George Giannakoulas[25], David G. Kiely[26,27,28], Eckhard Mayer[29], Gergely Meszaros[19,30], Blin Nagavci[31], Karen M. Olsson[32], Joanna Pepke-Zaba[33], Jennifer K. Quint[34], Göran Rådegran[35,36], Gerald Simonneau[37,38], Olivier Sitbon[2,37,39], Thomy Tonia[40], Mark Toshner[41], Jean-Luc Vachiery[42], Anton Vonk Noordegraaf[43], Marion Delcroix[44,46], Stephan Rosenkranz[45,46] and the ESC/ERS Scientific Document Group

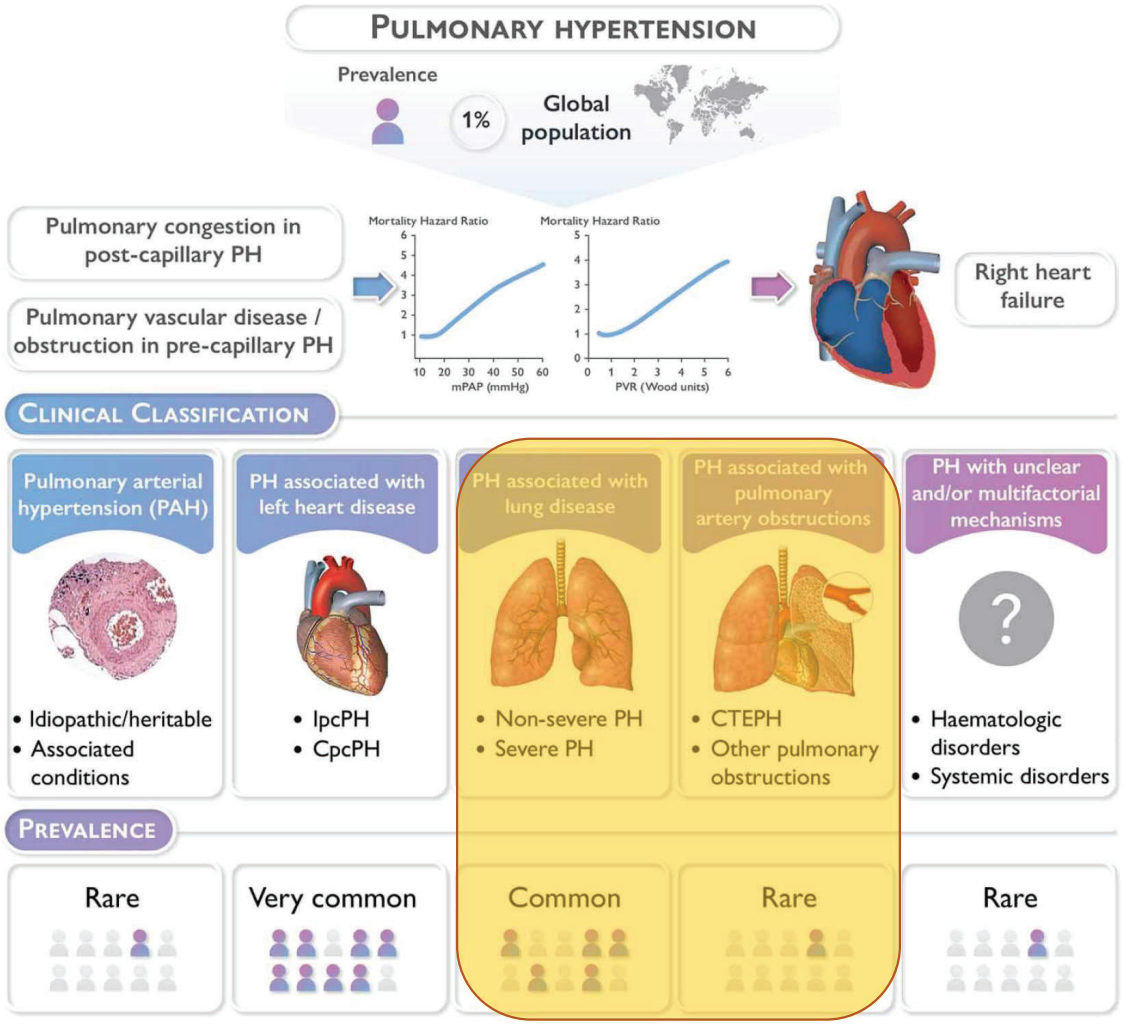
Eur Respir J 2023; 61: 2200879

TABLE 5 Haemodynamic definitions of pulmonary hypertension

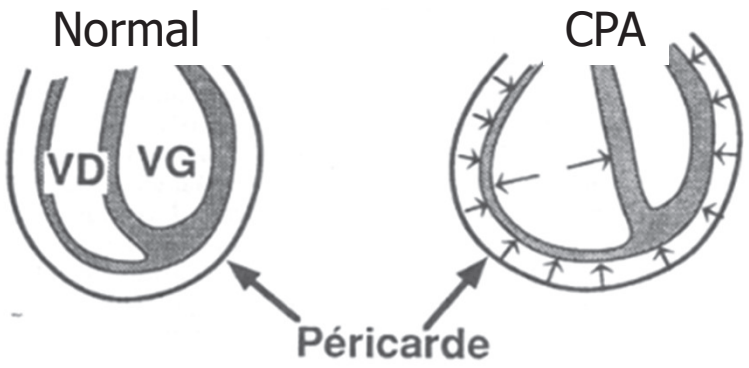
Definition	Haemodynamic characteristics
PH	mPAP >20 mmHg
Pre-capillary PH	mPAP >20 mmHg PAWP ⩽15 mmHg PVR >2 WU
IpcPH	mPAP >20 mmHg PAWP >15 mmHg PVR ⩽2 WU
CpcPH	mPAP >20 mmHg PAWP >15 mmHg PVR >2 WU
Exercise PH	mPAP/CO slope between rest and exercise >3 mmHg/L/min

CO, cardiac output; CpcPH, combined post- and pre-capillary pulmonary hypertension; IpcPH, isolated post-capillary pulmonary hypertension; mPAP, mean pulmonary arterial pressure; PAWP, pulmonary arterial wedge pressure; PH, pulmonary hypertension; PVR, pulmonary vascular resistance; WU, Wood units. Some patients present with elevated mPAP (>20 mmHg) but low PVR (⩽2 WU) and low PAWP (⩽15 mmHg); this haemodynamic condition may be described by the term ‘unclassified PH’ (see text for further details).

Définition


PULMONARY HYPERTENSION
Prevalence
1%
Global population
Pulmonary congestion in post-capillary PH
Pulmonary vascular disease / obstruction in pre-capillary PH
Mortality Hazard Ratio
mPAP (mmHg)
Mortality Hazard Ratio
PVR (Wood units)
Right heart failure
CLINICAL CLASSIFICATION
Pulmonary arterial hypertension (PAH)
• Idiopathic/heritable
• Associated conditions
PH associated with left heart disease
• IpcPH
• CpcPH
PH associated with lung disease
• Non-severe PH
• Severe PH
PH associated with pulmonary artery obstructions
• CTEPH
• Other pulmonary obstructions
PH with unclear and/or multifactorial mechanisms
• Haematologic disorders
• Systemic disorders
PREVALENCE
Rare
Very common
Common
Rare
Rare

Interdépendance ventriculaire

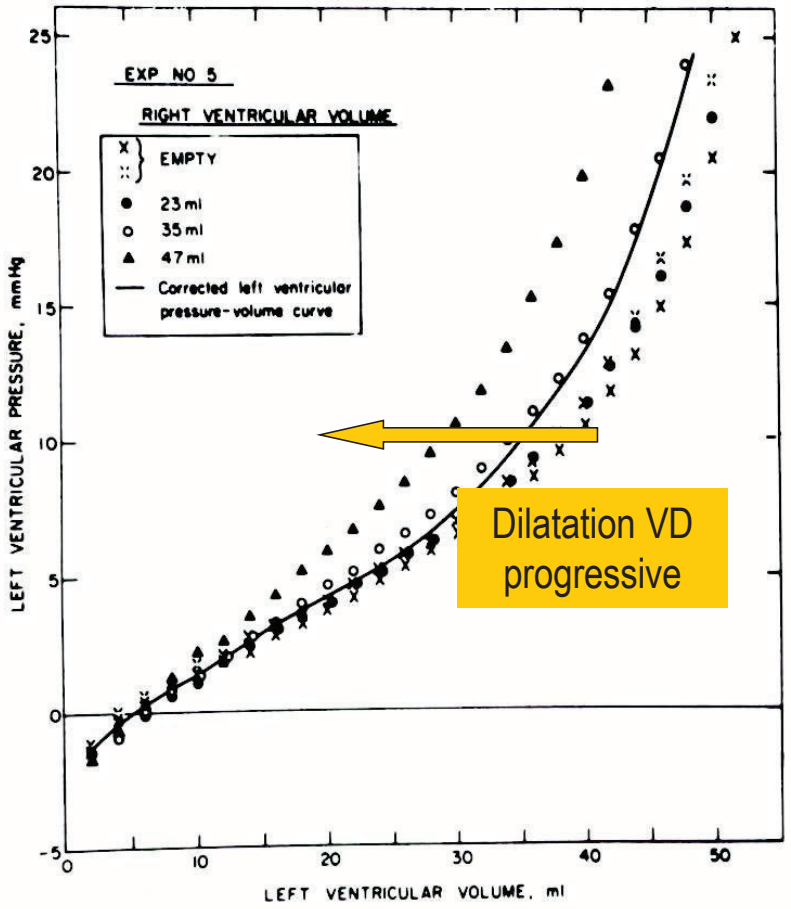


Cœur pulmonaire aigu :

- Seul le VD peut se dilater brutalement (paroi libre fine) suite à une augmentation de postcharge (ou à une baisse d'inotropisme)
- La somme des volumes télédiastoliques des ventricules est constante dans le péricarde inextensible
- Toute dilatation brutale du VD diminue le remplissage du VG, donc son éjection : risque de défaillance circulatoire +++

Gêne au remplissage du VG

L'augmentation progressive du volume VD décale la courbe de fonction diastolique VG vers la gauche : gêne au remplissage, donc à l'éjection VG (voire défaillance circulatoire)



Taylor AJP 1967

Insuffisance circulatoire

↑ RVP

↓

Dilatation VD *aiguë*

↓

Aplatissement du SIV

↓

Restriction du VG

↓

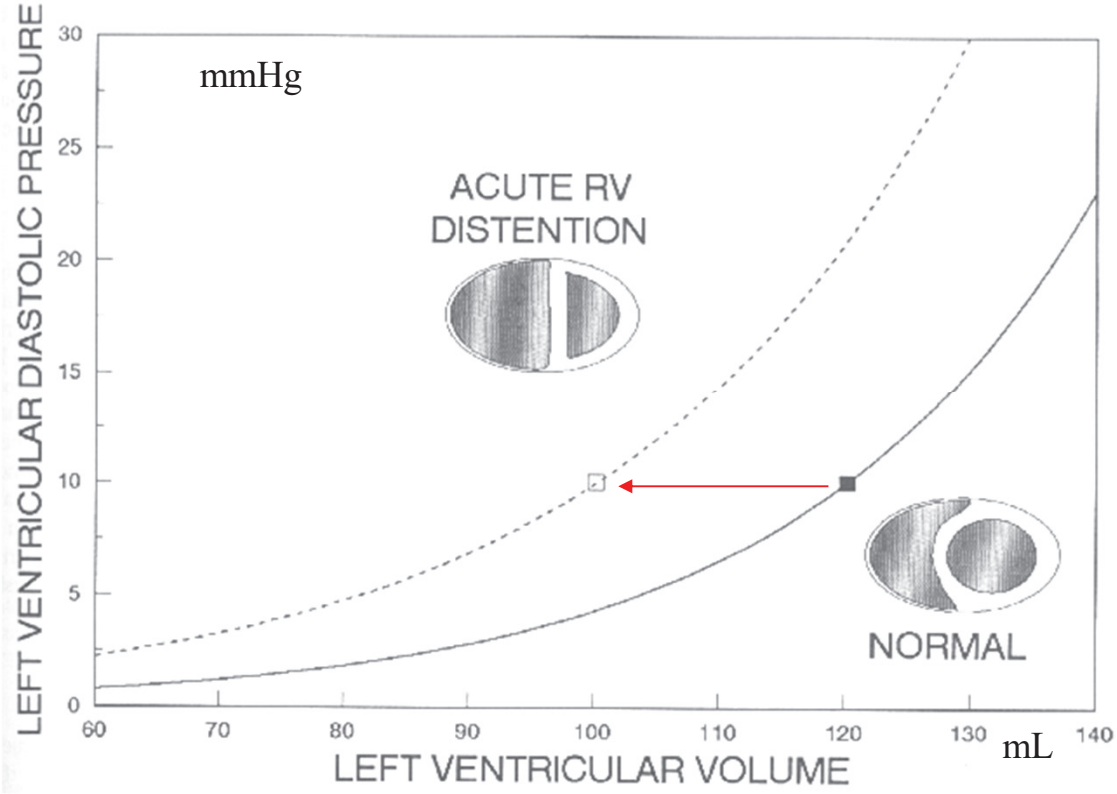
↓ remplissage diastolique

↓

↓ débit cardiaque systémique

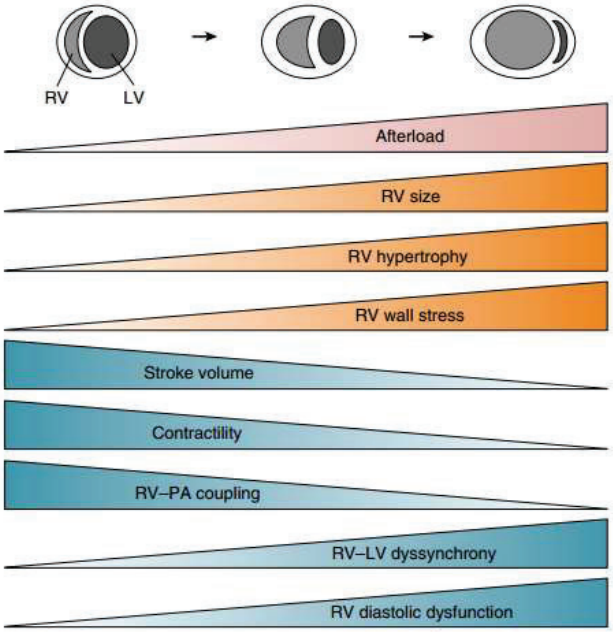
↓

Défaillance circulatoire



L Wood, J Hall. Principles in critical care

Atteinte VD : continuum



AMERICAN THORACIC SOCIETY DOCUMENTS

Assessment of Right Ventricular Function in the Research Setting: Knowledge Gaps and Pathways Forward

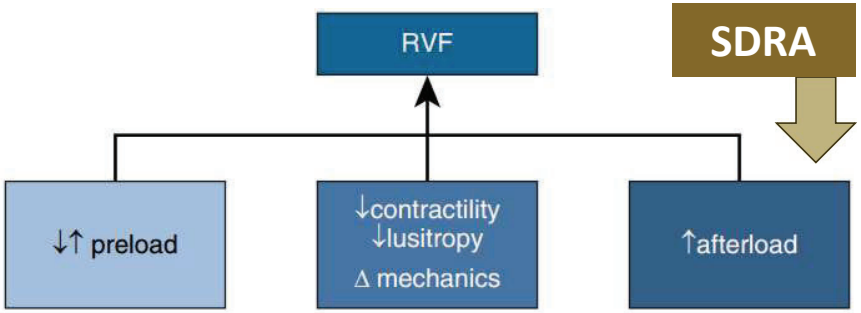
An Official American Thoracic Society Research Statement

Tim Lahm, Ivor S. Douglas, Stephen L. Archer, Harm J. Bogaard, Naomi C. Chesler, Francois Haddad, Anna R. Hemnes, Steven M. Kawut, Jeffrey A. Kline, Todd M. Kolb, Stephen C. Mathai, Olaf Mercier, Evangelos D. Michelakis, Robert Naeije, Rubin M. Tuder, Corey E. Ventetuolo, Antoine Vieillard-Baron, Norbert F. Voelkel, Anton Vonk-Noordegraaf, and Paul M. Hassoun; on behalf of the American Thoracic Society Assembly on Pulmonary Circulation

Am J Respir Crit Care Med Vol 198, Iss 4, pp e15–e43, Aug 15, 2018

RVF occurs as a consequence of *1)* alterations in preload; *2)* changes in RV mechanics, lusitropy, and/or contractility; or *3)* increases in afterload

- The task force defined RV failure (RVF) as a complex clinical syndrome characterized by insufficient delivery of blood from the RV in the setting of elevated systemic venous pressure at rest or exercise.
- RVF is a heterogeneous syndrome. Multiple RVF phenotypes exist.



Deux signes fondamentaux

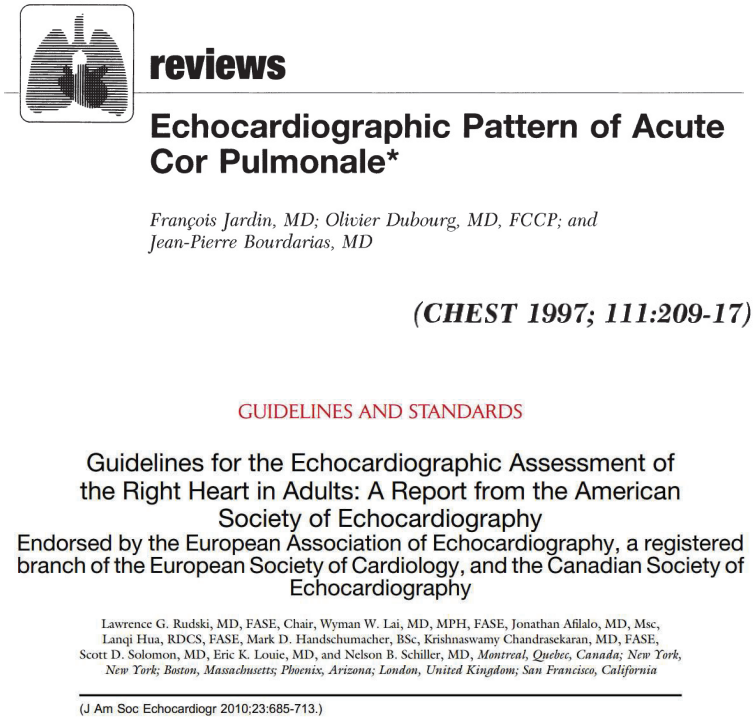
- Surcharge diastolique ou volumique du VD (dilatation) : le VD a une fonction diastolique « tolérante »
- Surcharge systolique ou barométrique du VD (aplatissement et mouvement paradoxal du septum interventriculaire) : le VD a une fonction systolique « sensible » (à toute élévation de postcharge).

Jardin F et al. Chest 1997;111:209-17

Diagnostic différentiel

- Cœur pulmonaire chronique :
  - ✓ Contexte +++
  - ✓ HTAP sévère (PAPs > 60 mmHg)
  - ✓ HVD (paroi libre > 7 voire 10 mm)
- Infarctus du VD
- Pièges exceptionnels : sténose pulmonaire, compression des artères pulmonaires (tumeurs, anévrysmes de l'aorte ascendante…), fistules vasculaires (aortopulmonaire…).

Acute cor pulmonale (1)



reviews

Echocardiographic Pattern of Acute Cor Pulmonale*

François Jardin, MD; Olivier Dubourg, MD, FCCP; and Jean-Pierre Bourdarias, MD

(CHEST 1997; 111:209-17)

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

Lawrence G. Rudski, MD, FASE, Chair, Wyman W. Lai, MD, MPH, FASE, Jonathan Afilalo, MD, Msc, Lanqi Hua, RDCS, FASE, Mark D. Handschumacher, BSc, Krishnaswamy Chandrasekaran, MD, FASE, Scott D. Solomon, MD, Eric K. Louie, MD, and Nelson B. Schiller, MD, *Montreal, Quebec, Canada; New York, New York; Boston, Massachusetts; Phoenix, Arizona; London, United Kingdom; San Francisco, California*

(J Am Soc Echocardiogr 2010;23:685-713.)

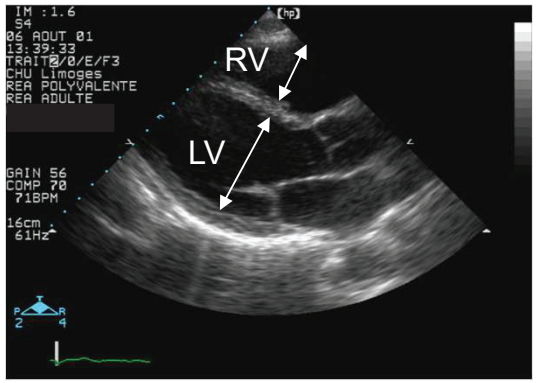
- ✓ ACP associates **RV dilatation** and **paradoxical septal motion**
- ✓ RV dilatation: ratio of **RV/LV end-diastolic area** (diameter)
- ✓ Criteria:
  - RV/LV end-diastolic dimension > 0.6
  - **Severe if RV/LV dimension > 1**
- ✓ Paradoxical septal motion at end-systole:
  - ✓ Reflects **pressure overload**
  - ✓ Confirmed by **eccentricity index**
  - ✓ Might be associated with RV **volume overload (end-diastole).**

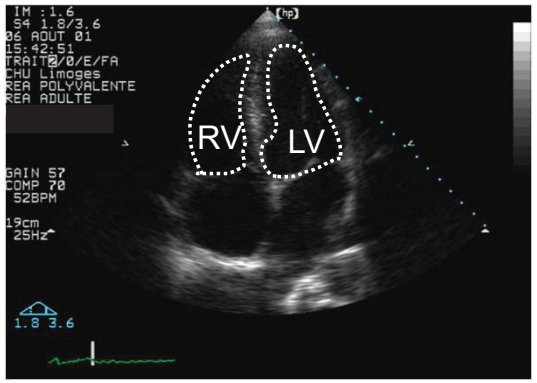
RV dilatation

Parasternal LAX

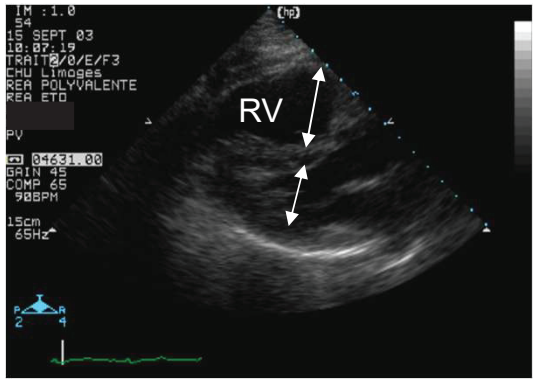
Apical 4-C

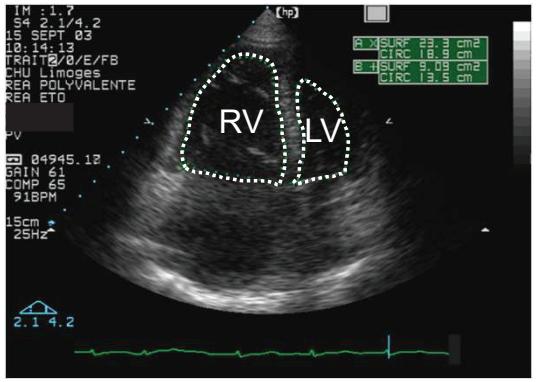
Normal

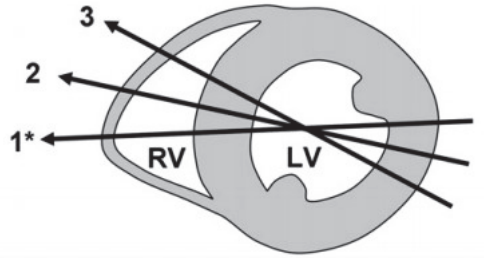


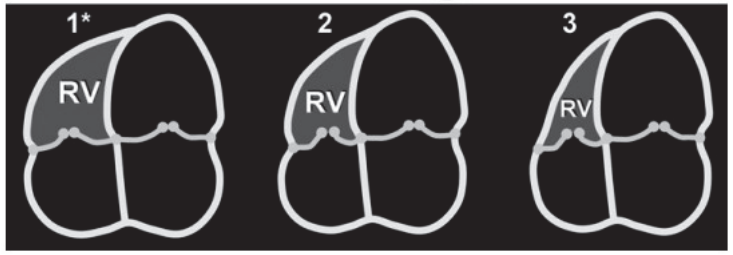


ACP

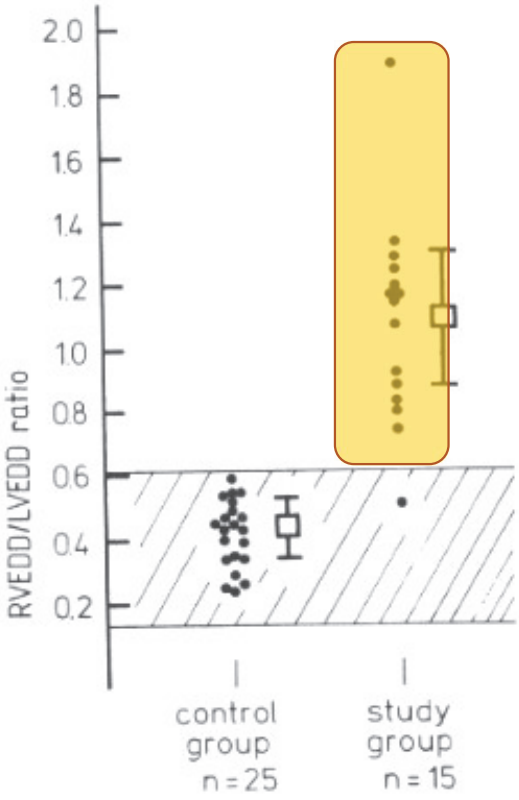




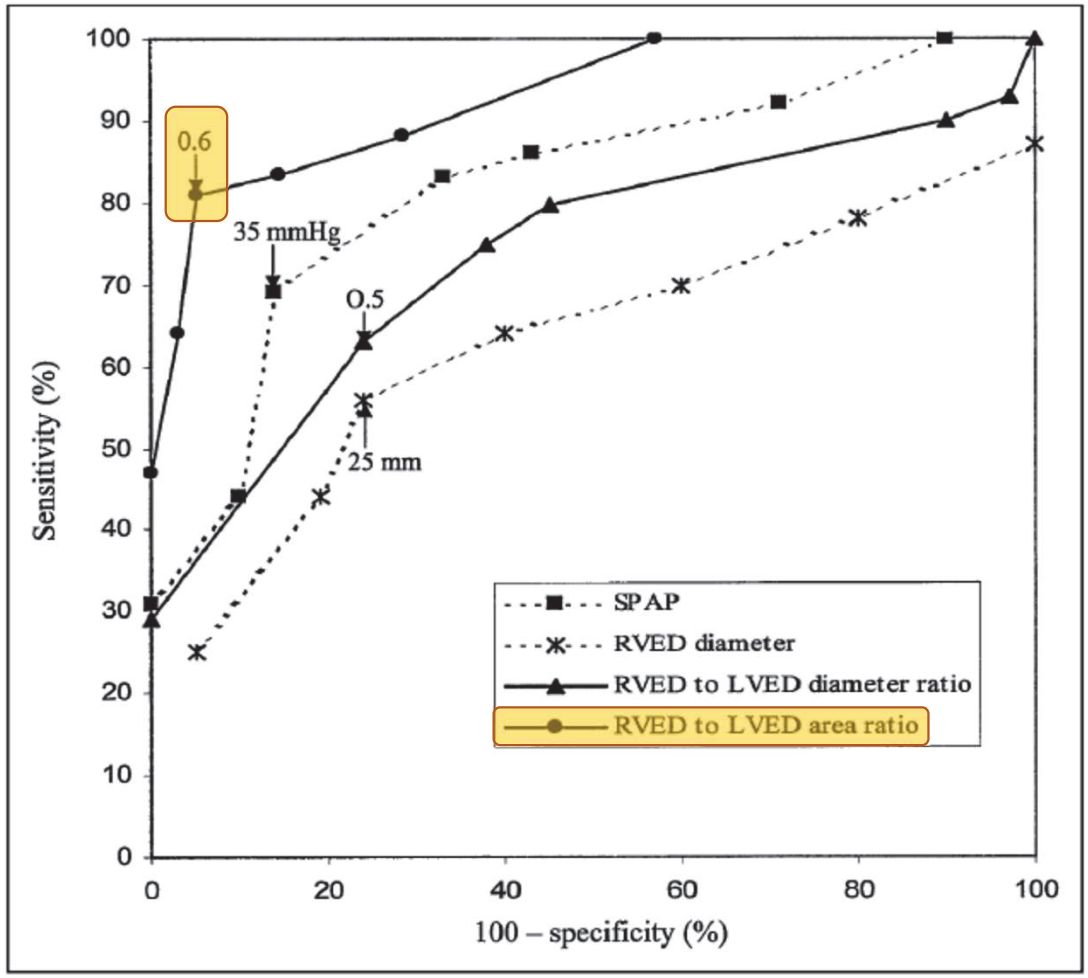




Parasternal LAX



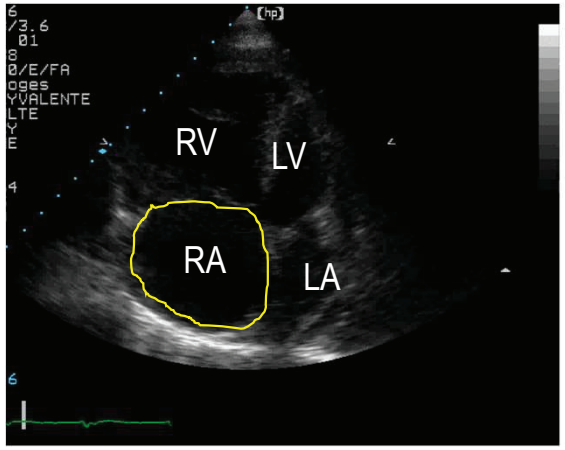
Kasper et al. Am J Cardiol 1980 ; 45 : 567-72



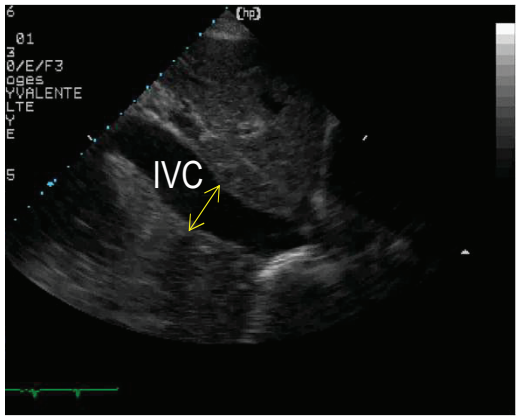
Mansencal et al. Am J Cardiol 2003 ; 92 : 116

RA & IVC dilatation

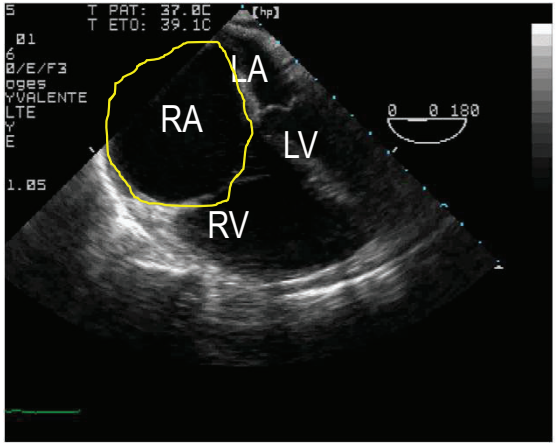
TTE



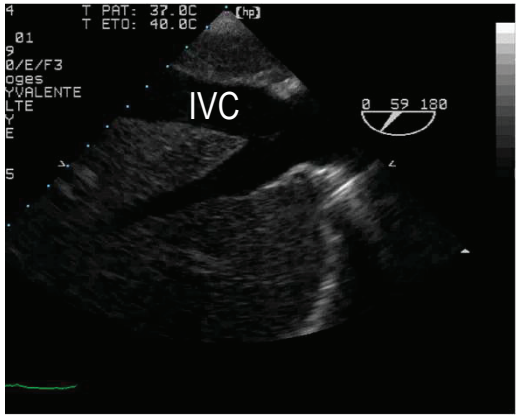
TTE



TEE

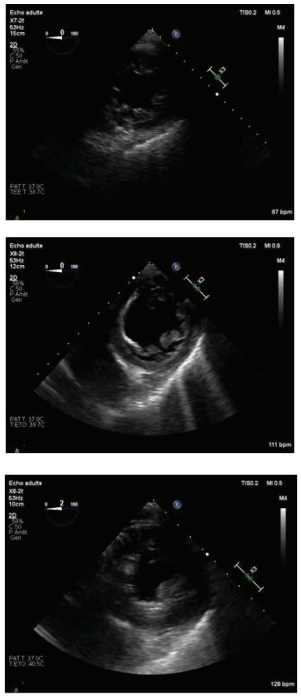


TEE



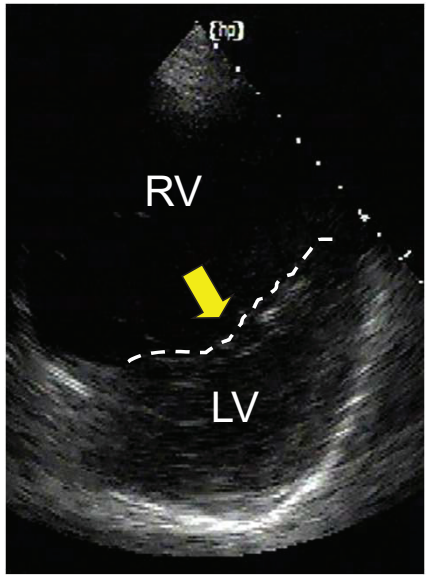
IVC ≤ 21 mm

Paradoxical septal motion



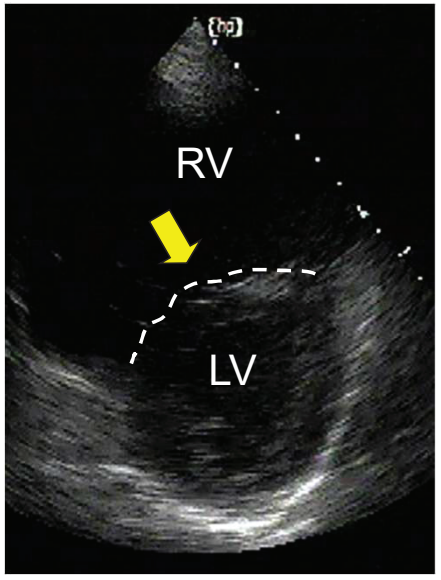
$P_{RV} > P_{LV}$

End-systole

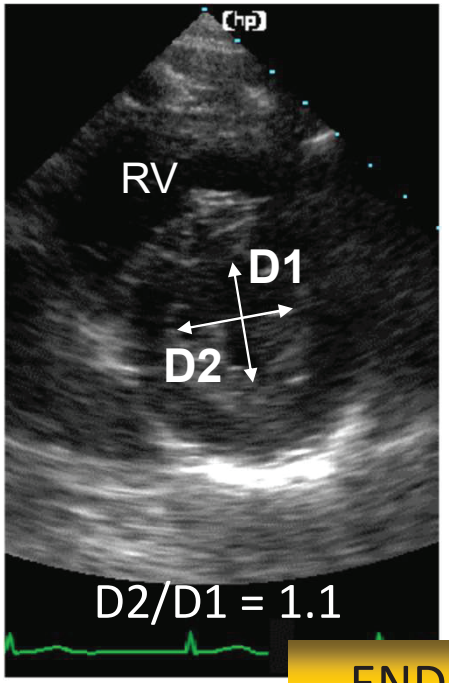


$P_{RV} < P_{LV}$

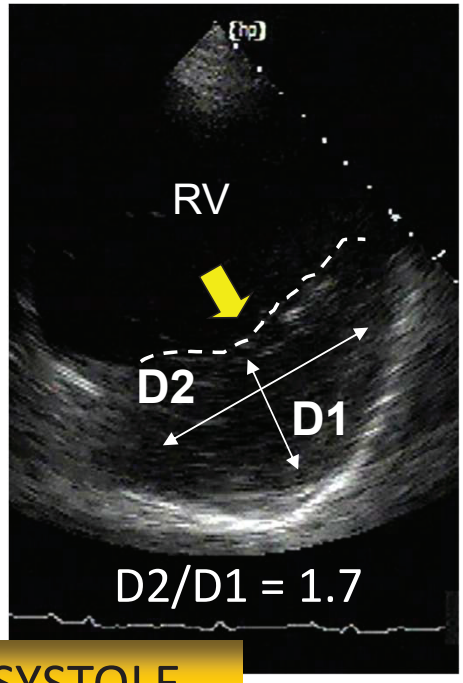
End-diastole



Normal

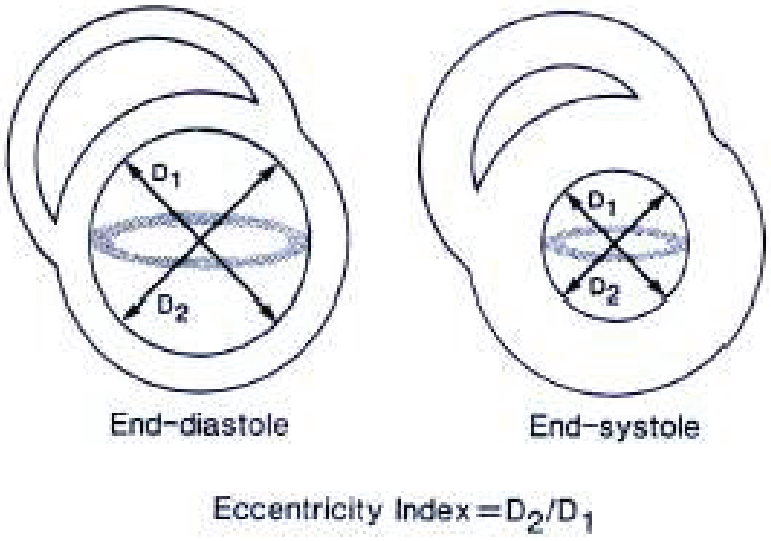


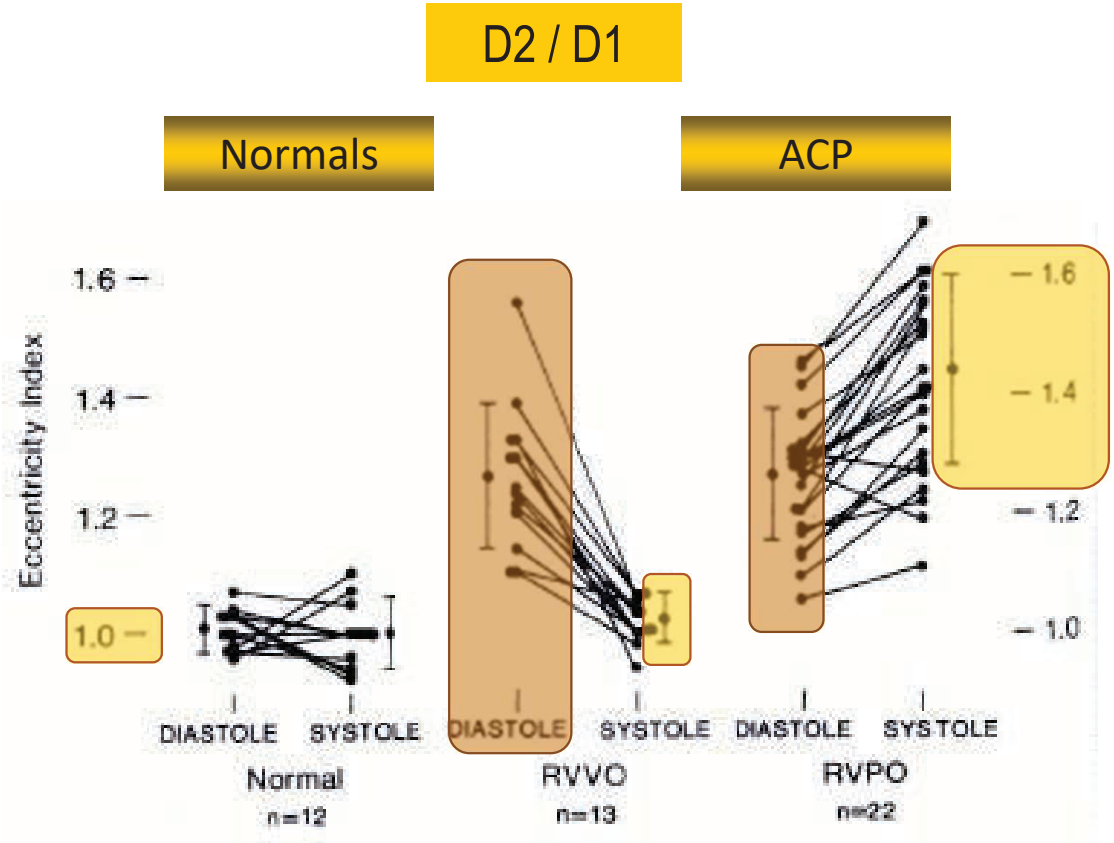
ACP



END-SYSTOLE

Eccentricity index



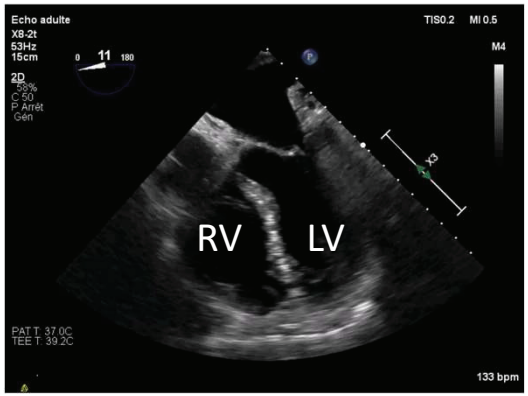


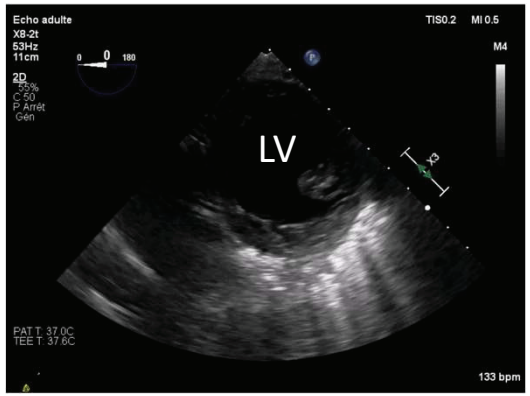
Ryan et al. J Am Coll Cardiol 1985; 5: 918-24

Acute cor pulmonale (2)

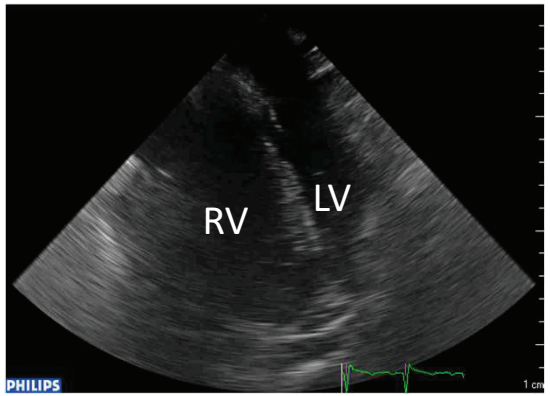
Moderate vs. severe

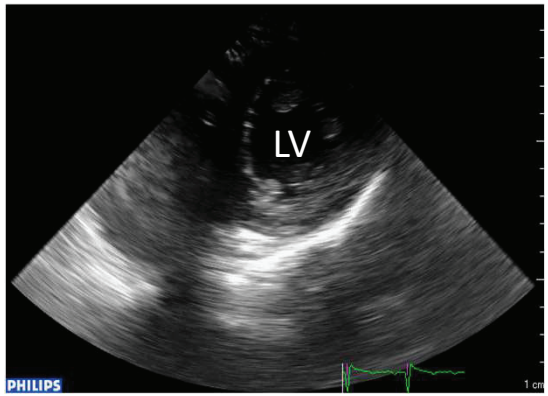
Moderate ACP





Severe ACP

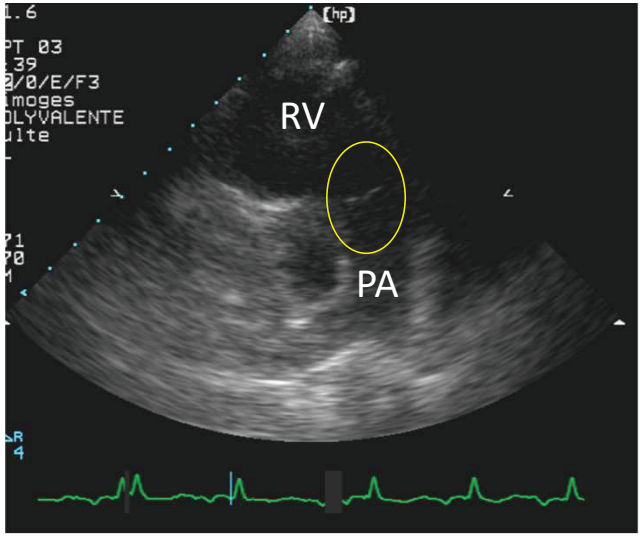




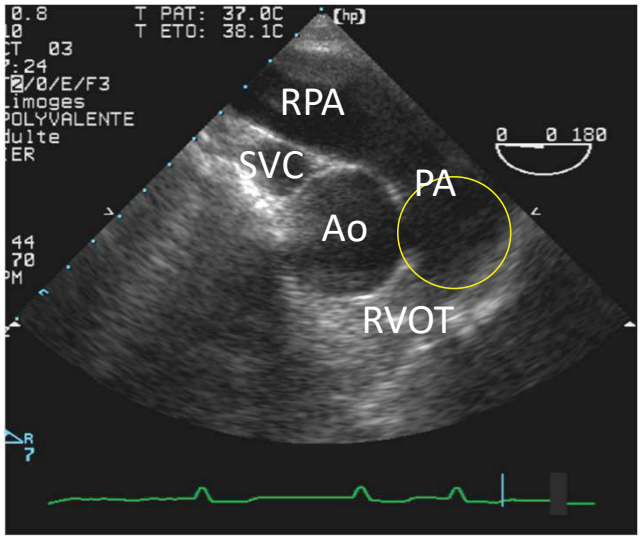
RVEDA/LVEDA > 1

Pulmonary artery Doppler profile (1)

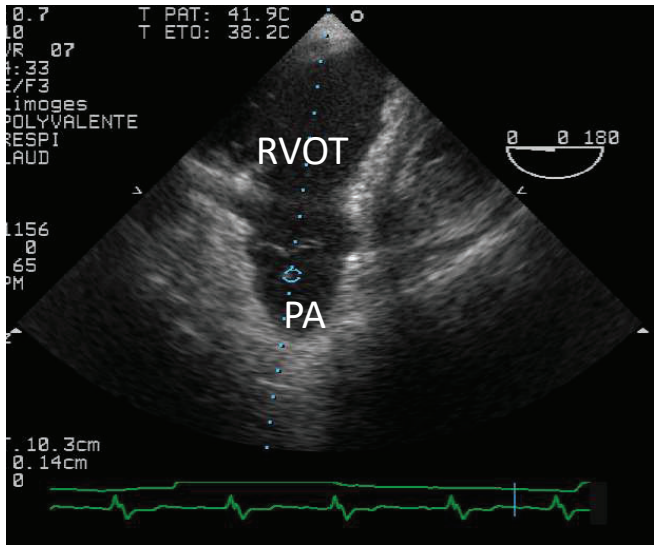
TTE



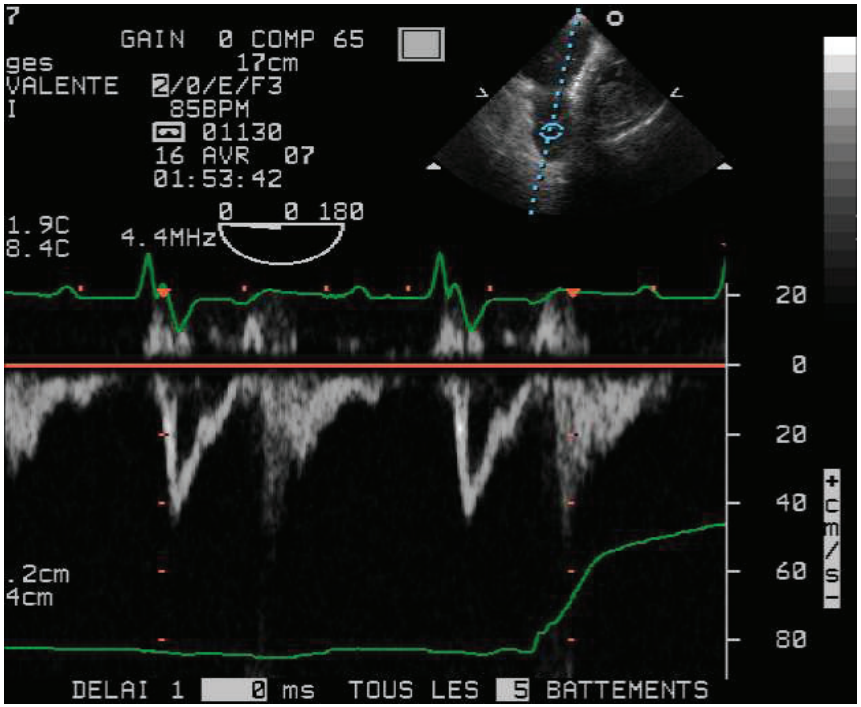
TEE

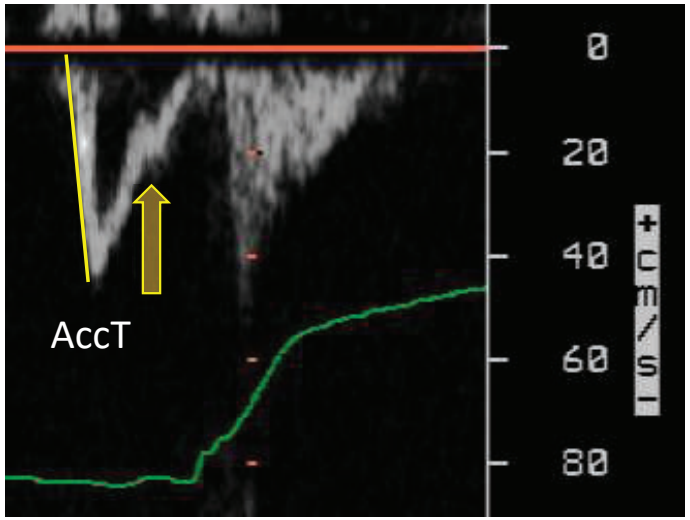


Pw Doppler positioning



Pulmonary artery Doppler profile (2)



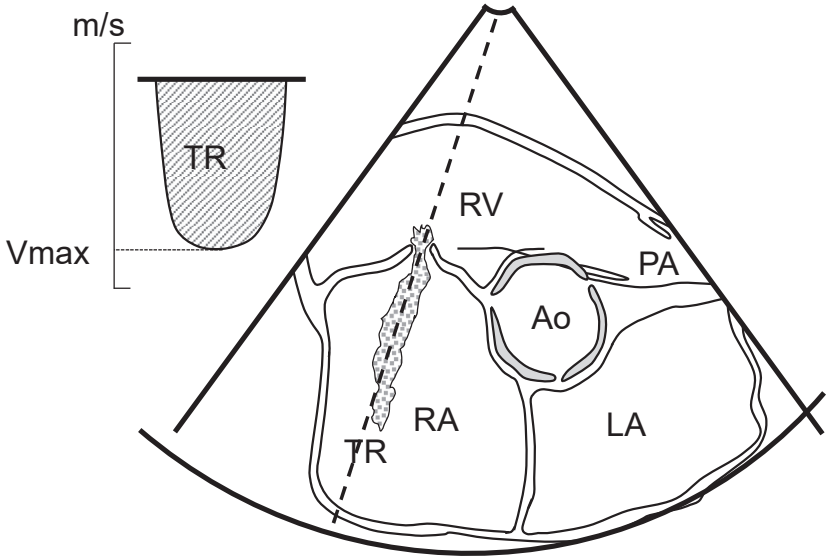


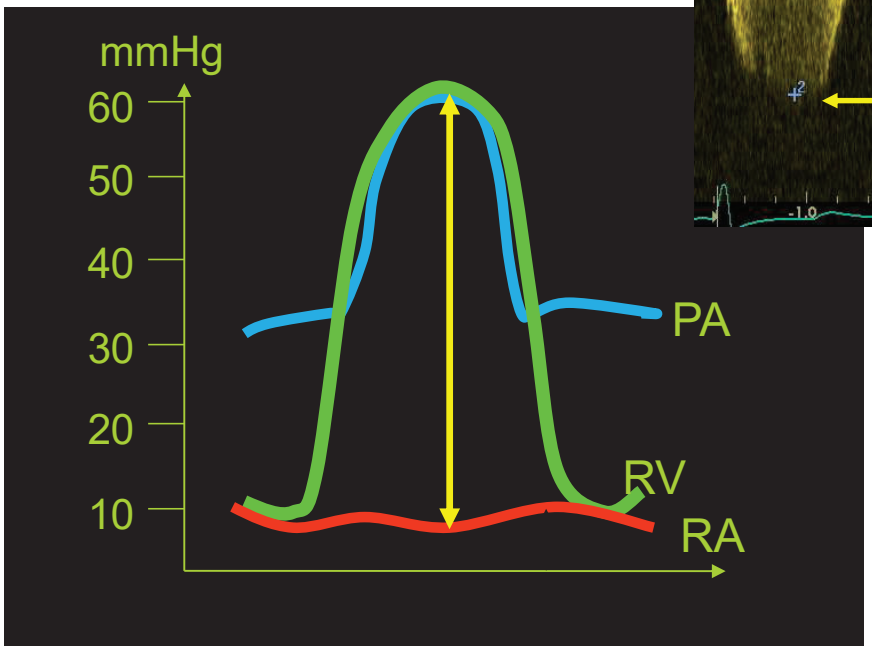
TR maximal velocity (1)

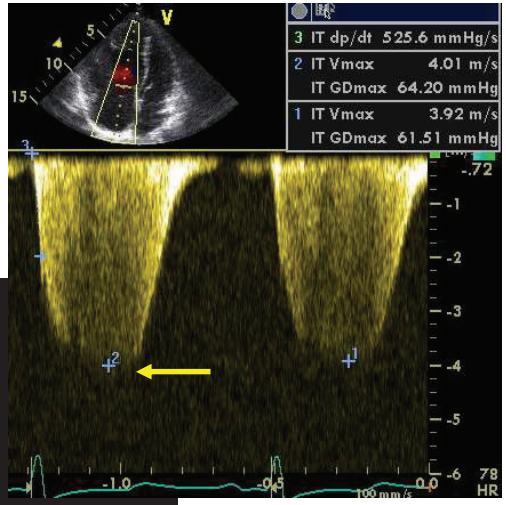
Assessment of Pulmonary Arterial Pressure Using Critical Care Echocardiography: Dealing With the Yin and the Yang?*

Crit Care Med 2019 ; 47 : 126-8

Philippe Vignon, MD, PhD

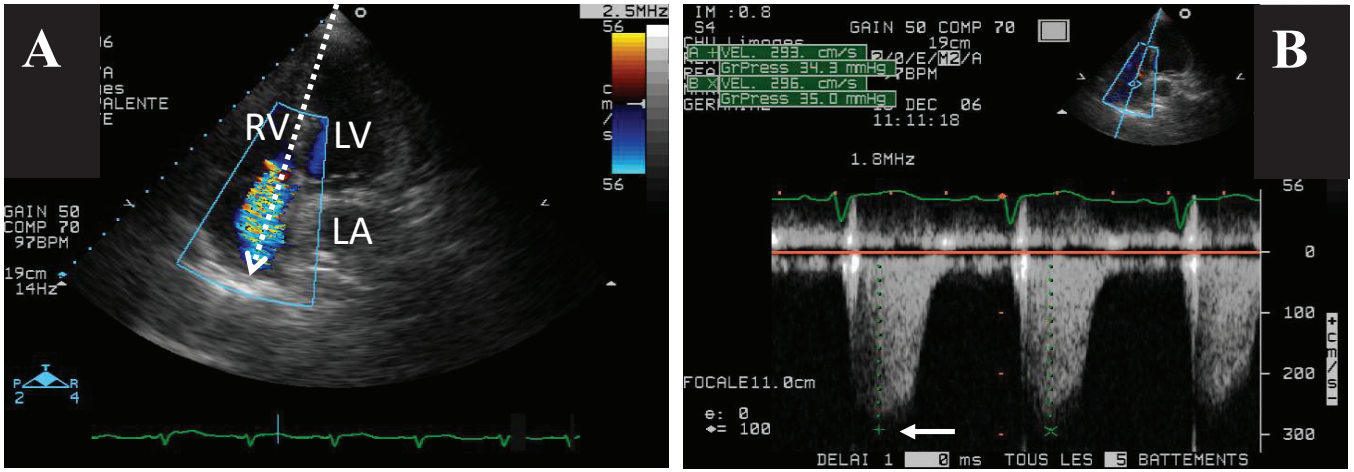






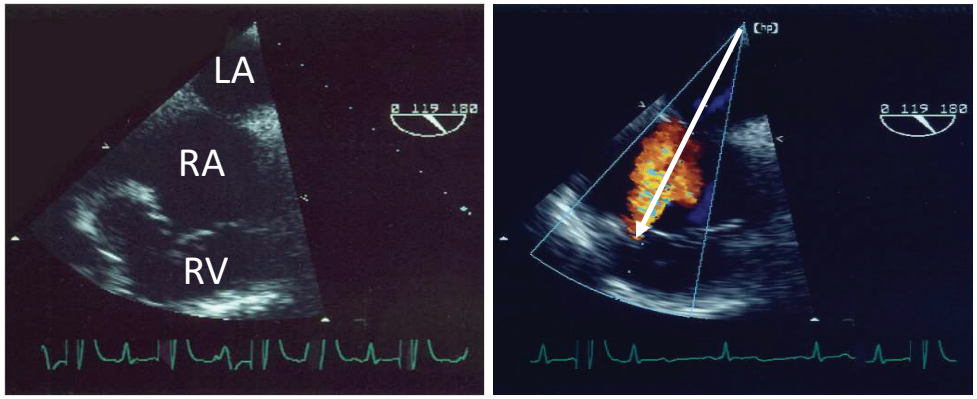
TR maximal velocity (2)

TTE



$sPAP \approx 4 \bullet (Vmax\ TR)^2 + CVP$

TEE



Typically:
40 to 60°

Acute pulmonary hypertension

Pulmonary embolism

TABLE 4. HEMODYNAMIC AND ECHO–DOPPLER DATA OBTAINED IN THREE GROUPS OF PATIENTS WITH MASSIVE PULMONARY EMBOLISM

	No Circulatory Failure* (*n* = 32)	Circulatory Failure without Acidosis† (*n* = 32)	Circulatory Failure with Acidosis‡ (*n* = 34)
RVEDA/LVEDA	1 ± 0.2	1.2 ± 0.3	1.4 ± 0.5§
HR, beats/min	88 ± 12	104 ± 14§	109 ± 18§
SI (Doppler) cm^3/m^2	31 ± 8	22 ± 8§	18 ± 8§
CI (Doppler), $L/min/m^2$	2.7 ± 0.7	2.2 ± 0.7	1.9 ± 0.9§
RVEDA, cm^2/m^2	15.8 ± 4.5	15.7 ± 3.3	15.9 ± 4
RVESA, cm^2/m^2	11.7 ± 3.8	11.7 ± 3.1	12 ± 3.3
LVEDV, cm^3/m^2	54.3 ± 11.3	41.3 ± 15.2§	37.7 ± 19.7§
LVESV, cm^3/m^2	26.4 ± 13.1	17.4 ± 7.8	19.8 ± 13.4
LVEF, %	54 ± 15	58 ± 11	49 ± 12
Ppa,s (Doppler), mm Hg	55 ± 18	48 ± 15	48 ± 16
E/A mitral	0.85 ± 0.26	0.80 ± 0.21	0.78 ± 0.20
IVC diam, mm	16 ± 6	19 ± 6	19 ± 5

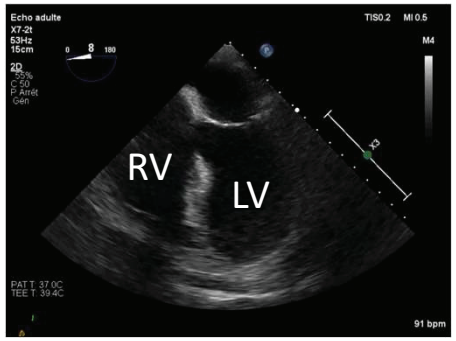
ARDS

TABLE 3. AVERAGE HEMODYNAMIC AND ECHO–DOPPLER DATA OBTAINED IN THREE GROUPS OF PATIENTS WITH ACUTE RESPIRATORY DISTRESS SYNDROME

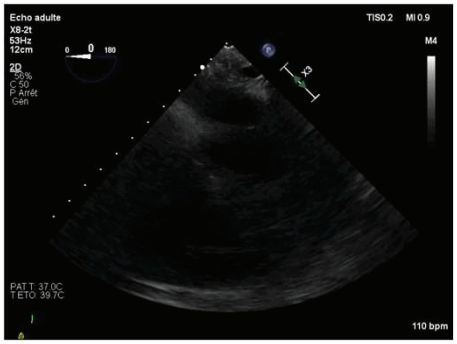
	No ACP* (*n* = 62)	Moderate ACP† (*n* = 13)	Severe ACP‡ (*n* = 6)
RVEDA/LVEDA	0.54 ± 0.12	0.81 ± 0.10§	1.2 ± 0.11§
HR, beats/min	100 ± 18	114 ± 9	100 ± 17
SI (Doppler), cm^3/m^2	32 ± 9	25 ± 8§	21 ± 4§
CI (Doppler), $L/min/m^2$	3.1 ± 0.9	2.8 ± 0.8	2 ± 0.8§
RVEDA, cm^2/m^2	8.6 ± 2.1	11.6 ± 2.8§	15.2 ± 3.5§
RVESA, cm^2/m^2	5.6 ± 1.9	7.6 ± 2.2§	11.7 ± 2.2§
LVEDV, cm^3/m^2	61 ± 16	45 ± 8§	43 ± 10§
LVESV, cm^3/m^2	29 ± 10	22 ± 10§	20 ± 8§
LVEF, %	52 ± 11	52 ± 17	53 ± 14
Ppa,s (Doppler), mm Hg	28 ± 11	51 ± 3§	44 ± 6§
E/A mitral	1.3 ± 0.4	0.8 ± 0.2	0.8 ± 0.1
IVC, diam mm	17 ± 5	19 ± 7	24 ± 3

Vieillard-Baron A et al. AJRCCM

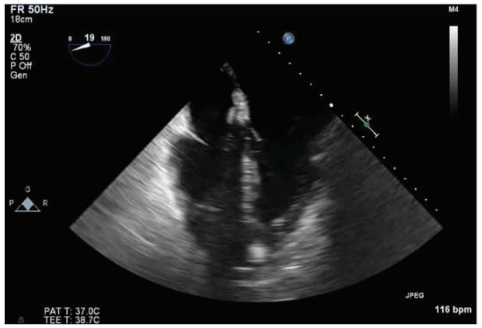
VD/VG : 0.7



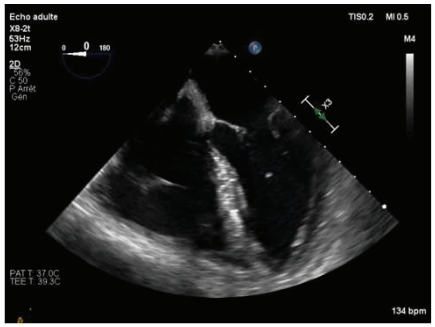
VD/VG : 0.8



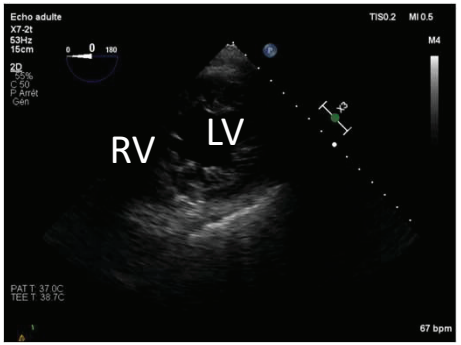
VD/VG : 1.1



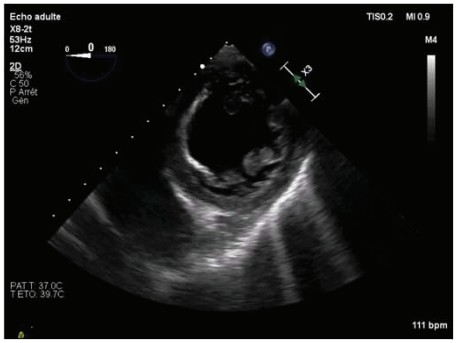
VD/VG : 1.3



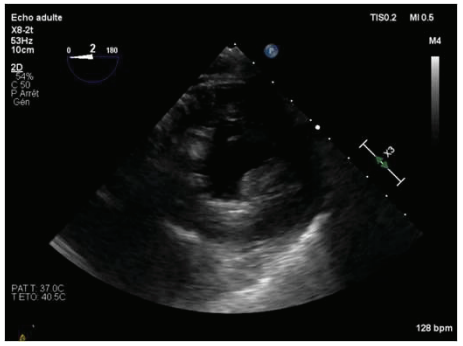
Septum normal



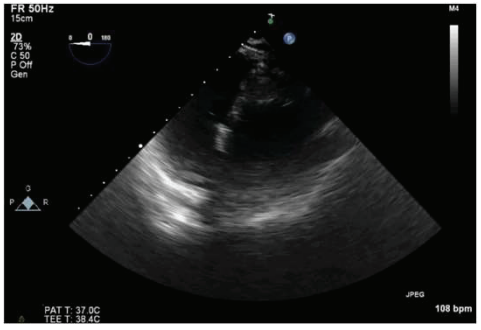
Septum grade 1



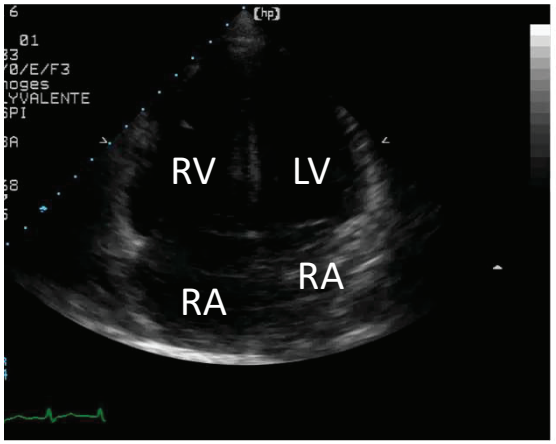
Septum grade 2



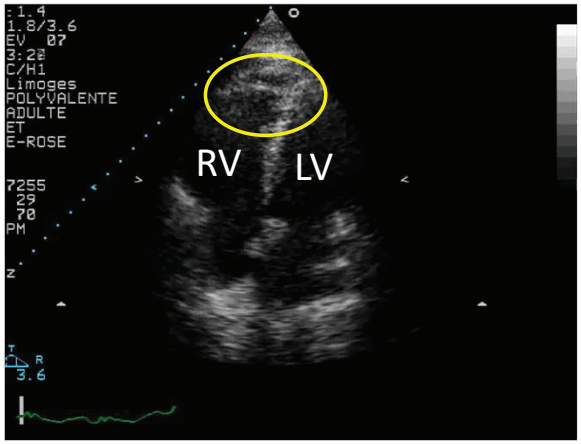
Septum grade 2



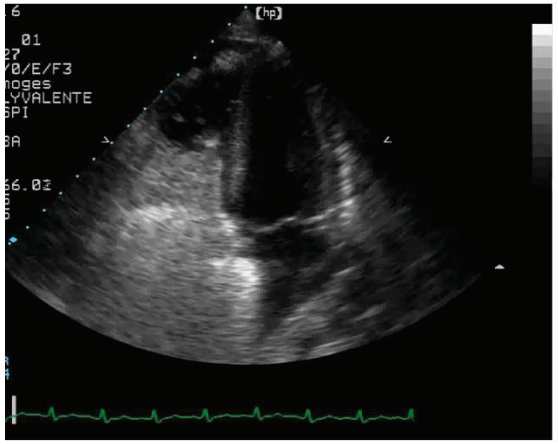
Severe ACP



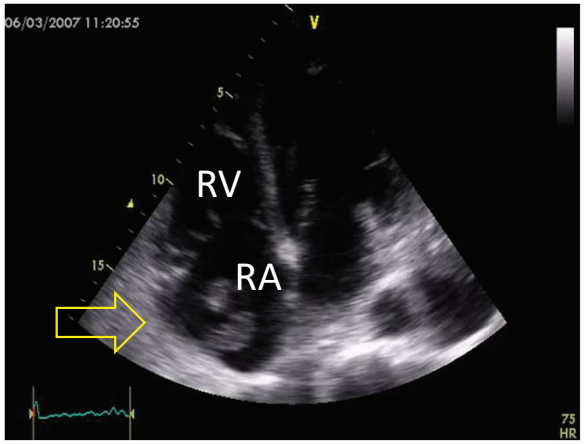
Mc Connell sign



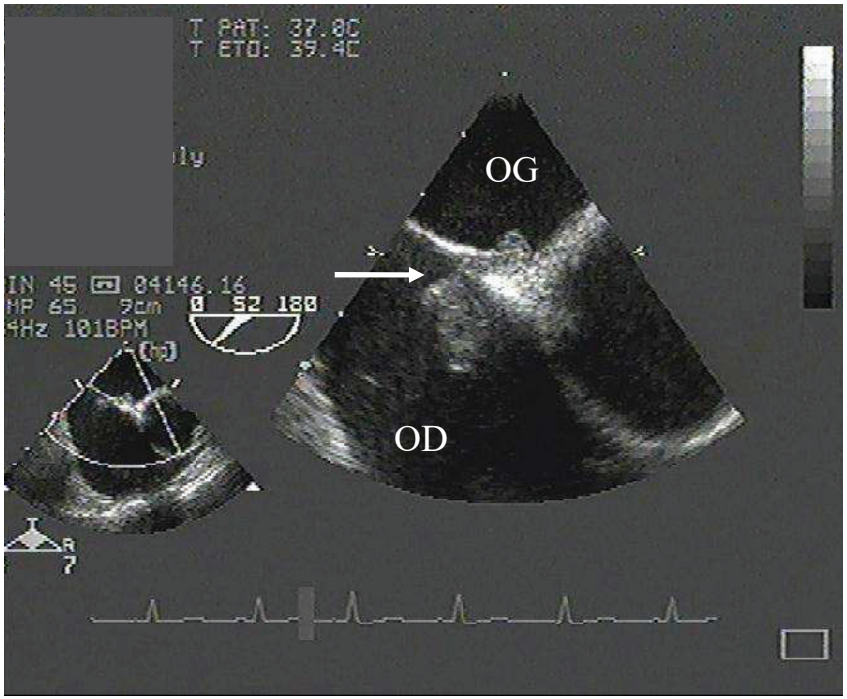
FOP

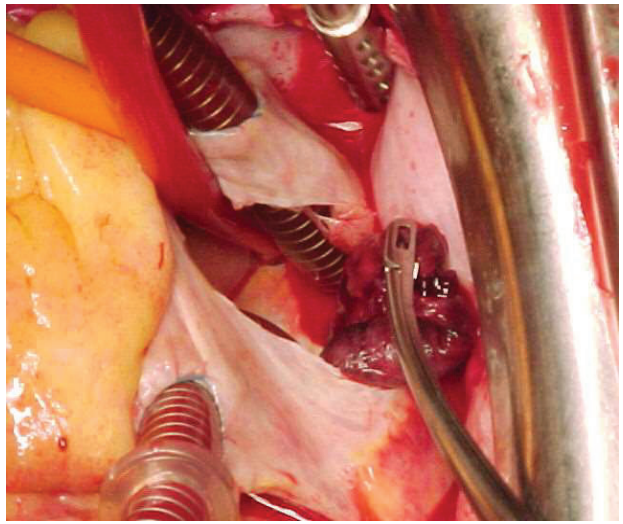


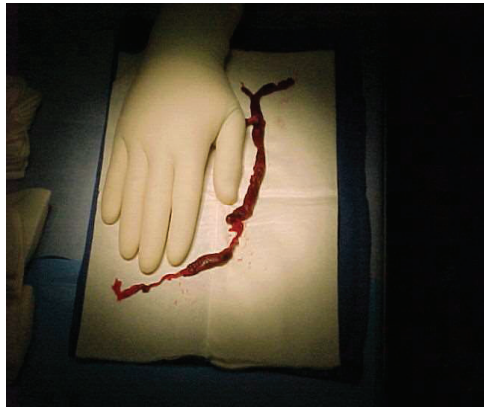
Thrombus-in-transit



Embole enclavé dans un FOP : ETO







Embole enclavé dans l'AP (ETO)

	Sensibilité	Spécificité
Vieillard-Baron et al. (n=19)	84%	84%
Pruszczyck et al. (n=49)	80%	100%
Wittlich et al. (n=60)	97%	88%
Steiner et al. (n=35)	82%	92%
Krivec et al. (n=12)	92%	100%

Vieillard-Baron A. et al. Intensive care Med 1997;24:429-33
Pruszczyck P. et al. Chest 1997;112:722-8
Wittlich N. et al. J Am Soc Echocardiogr 1992;5:515-24
Steiner P. et al. Am J Roentgenol 1996;167:931-6
Krivec B. et al. Chest 1997;112:1310-6.

Intensive Care Med (2013) 39:1734–1742
DOI 10.1007/s00134-013-3017-6

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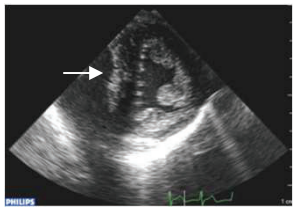
Prevalence and prognostic value of acute cor pulmonale and patent foramen ovale in ventilated patients with early acute respiratory distress syndrome: a multicenter study



- Multicentrique
- 200 patients SDRA persistant (P/F ≤ 200)
- Ventilation protectrice
- CPA : 22.5% (CI 95% : 16.9 – 28.9%)
- ARDS I documenté : 45%
- Autres sepsis : 9%

Intensive Care Med (2013) 39:1725–1733
DOI 10.1007/s00134-013-2941-9

ORIGINAL

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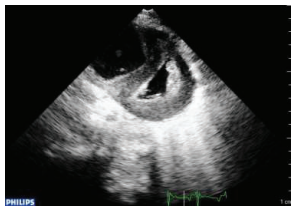
Prevalence and prognosis of cor pulmonale during protective ventilation for acute respiratory distress syndrome



- Monocentrique
- 236 patients SDRA (P/F ≤ 200)
- Ventilation protectrice
- CPA : 22% (CI 95% : 16 – 27%)
- ARDS I documenté : 53%
- Autres sepsis : 10%

Intensive Care Med (2013) 39:1734–1742
DOI 10.1007/s00134-013-3017-6

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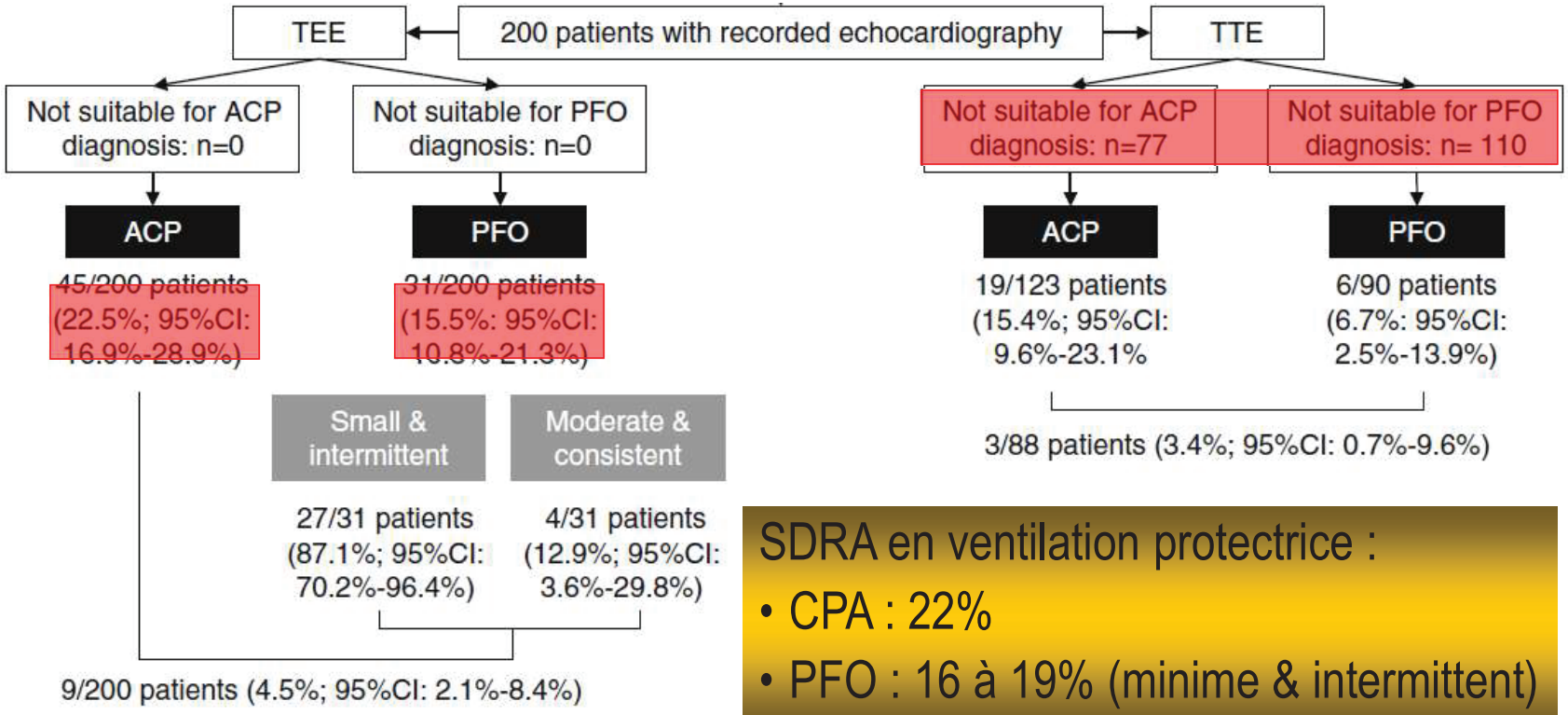
Prevalence and prognostic value of acute cor pulmonale and patent foramen ovale in ventilated patients with early acute respiratory distress syndrome: a multicenter study



SDRA en ventilation protectrice :

- CPA : 22%
- PFO : 16 à 19% (minime & intermittent)

Intensive Care Med
DOI 10.1007/s00134-015-4141-2

SEVEN-DAY PROFILE PUBLICATION

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Christian Brun-Buisson
Philippe Vignon
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Acute cor pulmonale during protective ventilation for acute respiratory distress syndrome: prevalence, predictors, and clinical impact

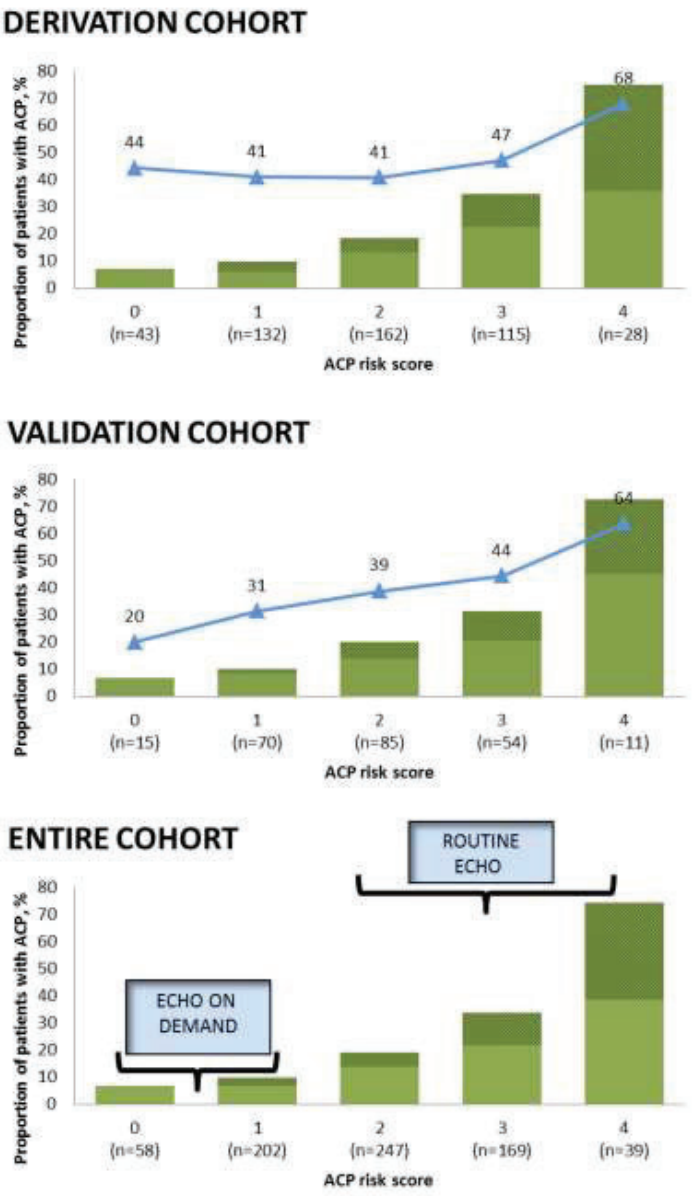
- Trois séries de patients en SDRA modéré à sévère (P/F ≤ 200) sous VM protectrice
- 752 patients avec une incidence du CPA : 22% (CI 95% : 19 – 25%)
- Seul le CPA sévère (VD/VG > 1) est associé à la mortalité

Table 4 Factors associated with hospital mortality in patients with acute respiratory distress syndrome

Variable	Odds ratio (95 % CI)	
	Univariate logistic regression	Multivariable logistic regression[a]
Male gender	1.35 (0.99–1.84), $p = 0.06$	1.46 (1.01–2.11), $p = 0.045$
Age ≥58 years	2.33 (1.73–3.14), $p < 0.01$	2.42 (1.71–3.45), $p < 0.01$
SAPS II ≥56 points	2.79 (2.06–3.76), $p < 0.01$	1.88 (1.32–2.69), $p < 0.01$
Respiratory settings on TEE day		
Respiratory rate ≥30 cycles/min	2.06 (1.41–3.02), $p < 0.01$	3.29 (2.07–5.22), $p < 0.01$
PEEP ≥12 cmH_2O	0.64 (0.45–0.91), $p = 0.01$	I/NR
Plateau pressure ≥25 cmH_2O	1.40 (1.04–1.89), $p = 0.03$	I/NR
Compliance <35 ml/cmH_2O	1.46 (1.07–2.00), $p = 0.02$	I/NR
Driving pressure ≥15 cmH_2O	1.90 (1.40–2.58), $p < 0.01$	2.26 (1.58–3.23), $p < 0.01$
PaO_2/FiO_2 ratio <100 mmHg on TEE day	1.45 (1.09–1.95), $p = 0.01$	1.45 (1.02–2.08), $p = 0.04$
Severe cor pulmonale	1.89 (1.08–3.30), $p = 0.03$	2.00 (1.03–3.88), $p = 0.04$
Shock on TEE day	3.25 (2.32–4.56), $p < 0.01$	2.57 (1.73–3.80), $p < 0.01$
Prone position during ARDS	0.72 (0.52–0.99), $p = 0.045$	0.56 (0.37–0.84), $p < 0.01$

Table 3 The acute cor pulmonale risk score

Parameter	Score
Pneumonia as cause of ARDS	1
Driving pressure ≥18 cmH_2O[a]	1
PaO_2/FiO_2ratio <150 mmHg	1
$PaCO_2$ ≥48 mmHg	1
Total score	0–4



EUROPEAN RESPIRATORY JOURNAL
ERS OFFICIAL DOCUMENTS
M. HUMBERT ET AL.

2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension

Developed by the task force for the diagnosis and treatment of pulmonary hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS)

Endorsed by the International Society for Heart and Lung Transplantation (ISHLT) and the European Reference Network on rare respiratory diseases (ERN-LUNG)

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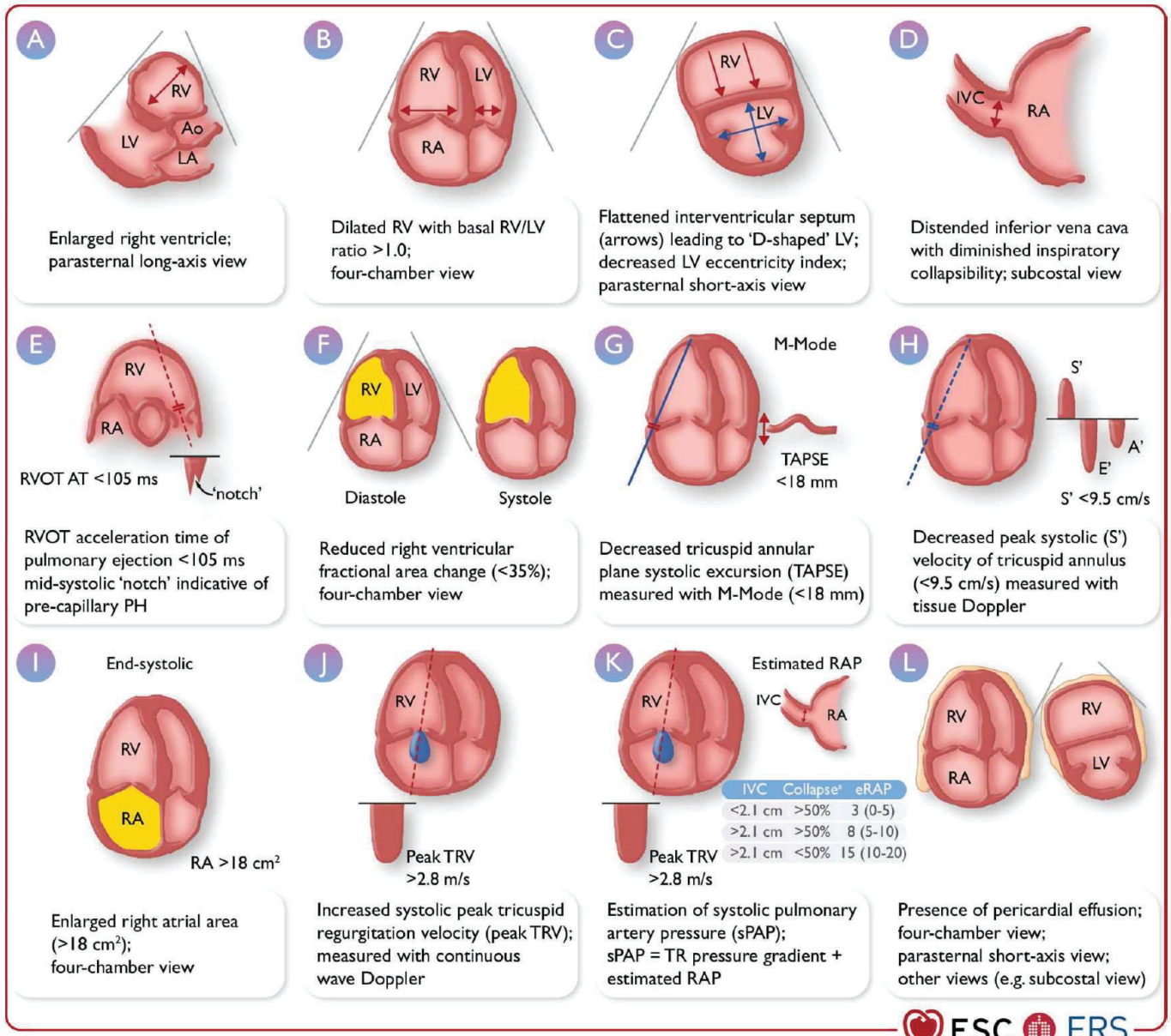
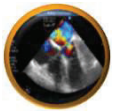


ESC ERS

Acute cor pulmonale



- ✓ RV **diastolic** impairment: **dilatation** of right cardiac cavities & IVC ± **volume overload (TR)**
- ✓ RV **systolic** impairment: **paradoxical septal motion (end-systole)**
- ✓ **Acute cor pulmonale (ACP)** associates RV dilatation and paradoxical septal motion
- ✓ ACP links RV dilatation to excessive afterload
- ✓ Pulmonary artery pressure can be assessed using Bernouilli's equation (TR & PR)
- ✓ Increase of RV afterload leads to **progressive VA uncoupling (RV failure)**
- ✓ Systemic venous congestion can be assessed (IVC size & respiratory variation, VExUS).