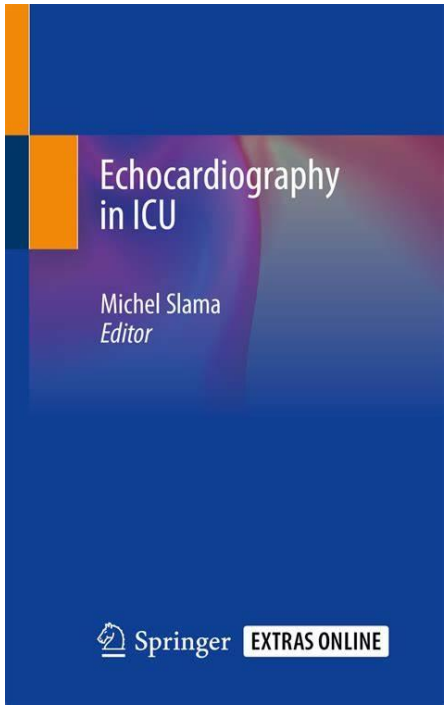
Respiratory failure: How to assess using Echocardiography?

Michel Slama

Amiens

France


Echocardiography
in ICU
Michel Slama
Editor
Springer
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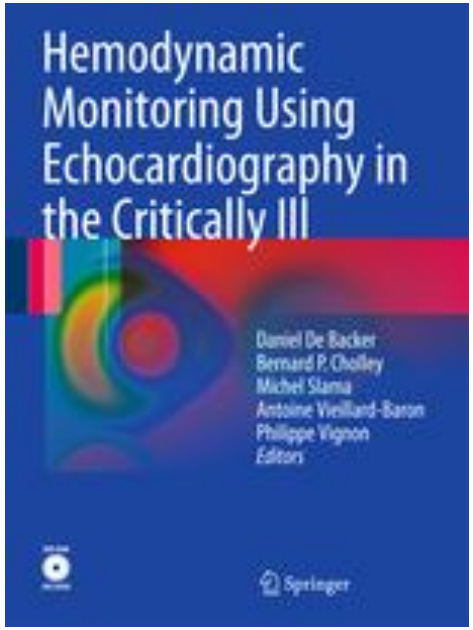
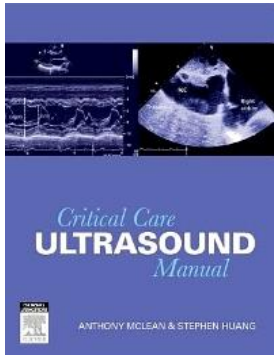
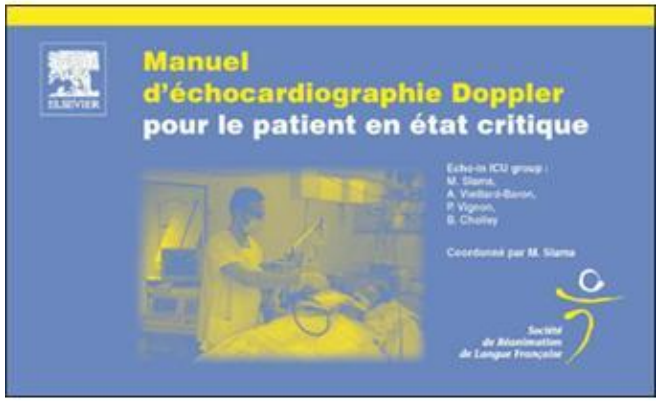
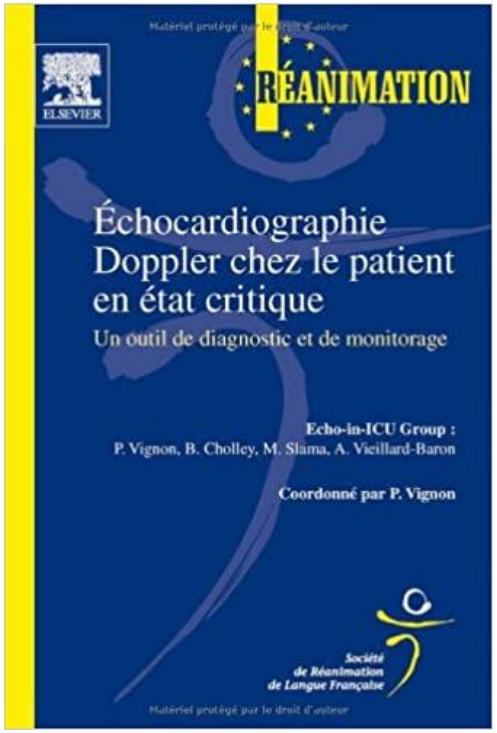

Hemodynamic
Monitoring Using
Echocardiography in
the Critically Ill
Daniel De Backer
Bernard P. Cholley
Michel Slama
Antoine Vieillard-Baron
Philippe Vignon
Editors
Springer


Critical Care
ULTRASOUND
Manual
ANTHONY MCLEAN & STEPHEN HUANG


Manuel
d'échocardiographie Doppler
pour le patient en état critique
Echo-in ICU group :
M. Slama,
A. Vieillard-Baron,
P. Vignon,
B. Cholley
Coordonné par M. Slama
Société
de Réanimation
de Langue Française


RÉANIMATION
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Doppler chez le patient
en état critique
Un outil de diagnostic et de monitorage
Echo-in-ICU Group :
P. Vignon, B. Cholley, M. Slama, A. Vieillard-Baron
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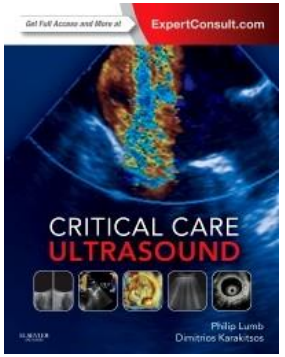
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CRITICAL CARE
ULTRASOUND
Philip Lumb
Dimitrios Karakitsos

Step 1: rule out pneumothorax hemothorax, unilateral pneumoniae

CHEST
Official publication of the American College of Chest Physicians

CHEST ONLINE

A Bedside Ultrasound Sign Ruling Out Pneumothorax in the Critically Ill : Lung Sliding

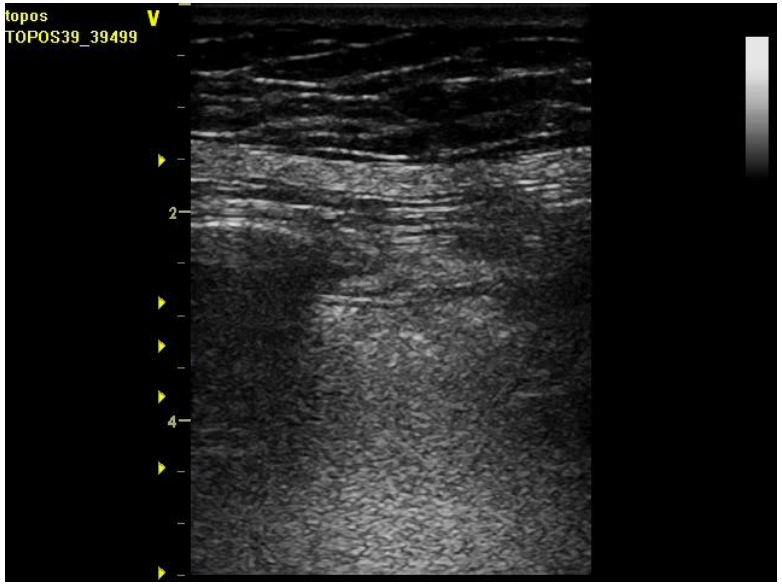
Daniel A. Lichtenstein and Yves Menu

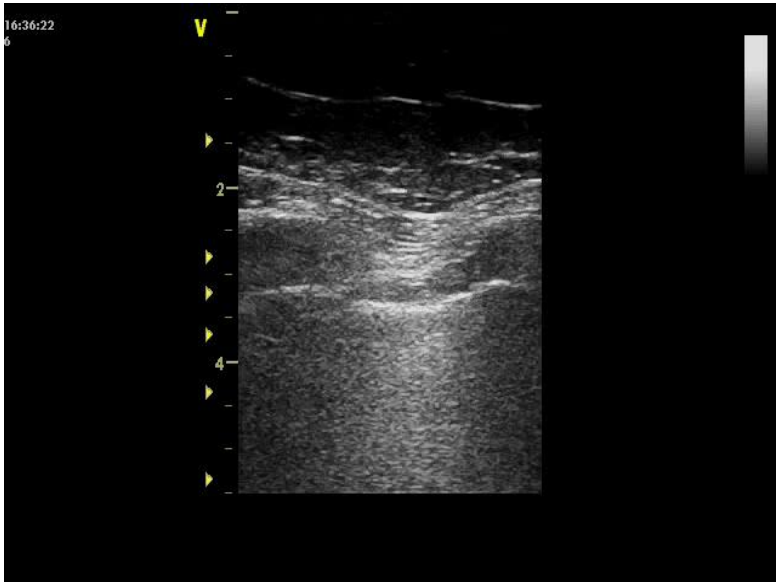
Intensive Care Med (2000) 26: 1434–1440
DOI 10.1007/s001340000627

ORIGINAL

Daniel Lichtenstein
Gilbert Mezière
Philippe Biderman
Agnès Gepner

The "lung point": an ultrasound sign specific to pneumothorax





Sliding Lung = no pneumothorax

Sliding Lung + lung point = pneumothorax

ELSEVIER

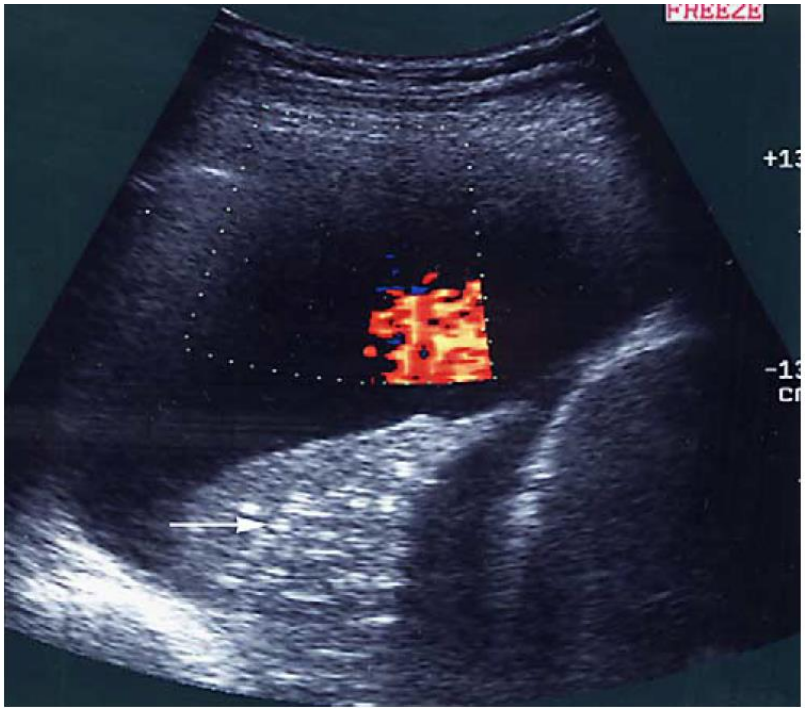
European Journal of Radiology 53 (2005) 463–470

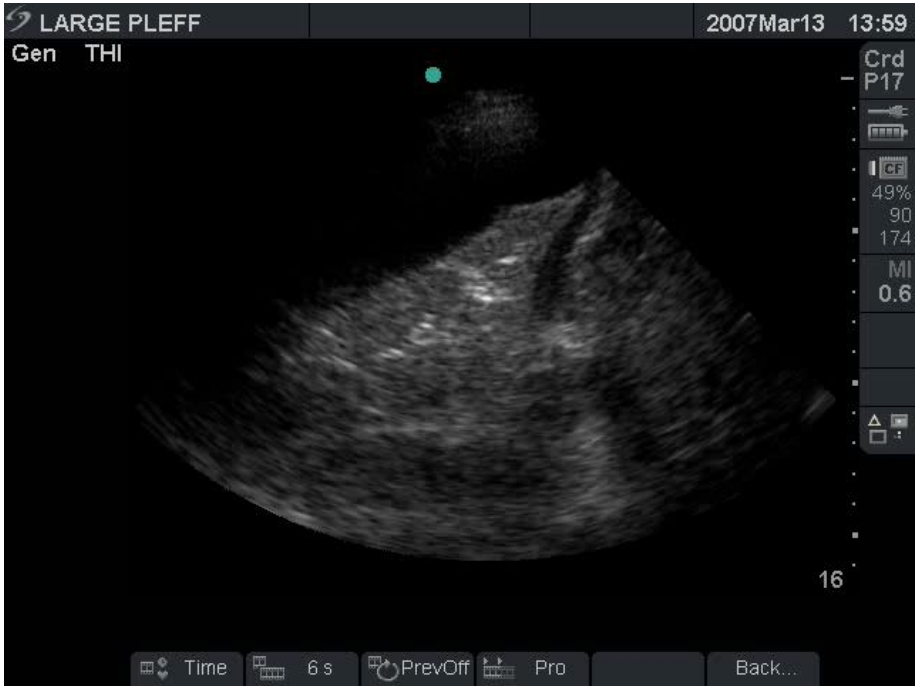
EJR
EUROPEAN JOURNAL OF RADIOLOGY

www.elsevier.com/locate/ejrad

Accuracy of transthoracic sonography in excluding post-interventional pneumothorax and hydropneumothorax
Comparison to chest radiography

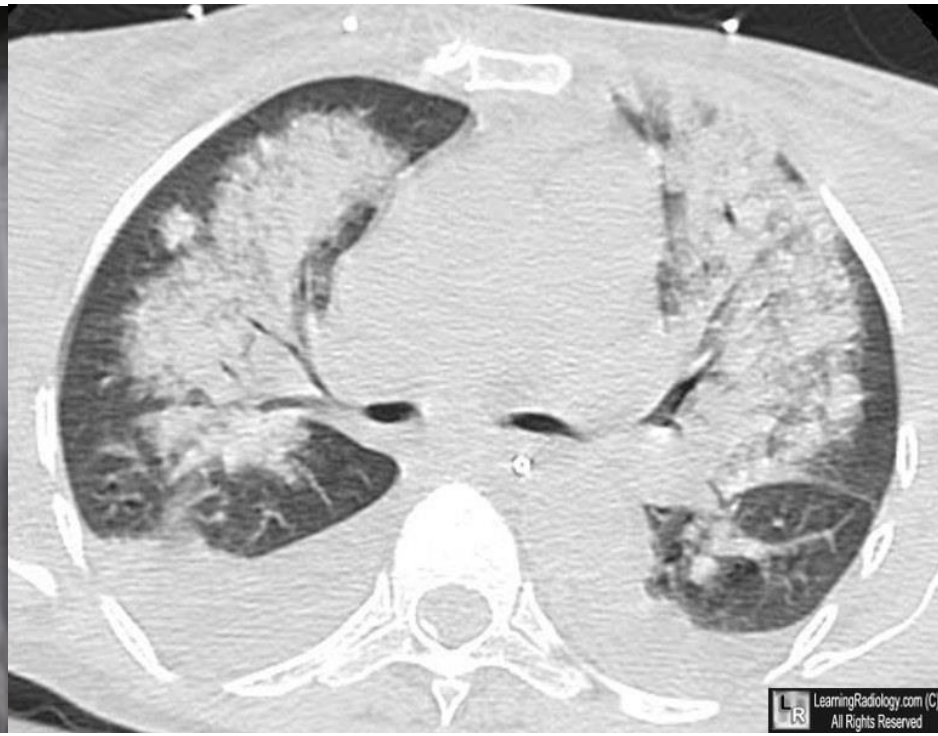
Angelika Reißig*, Claus Kroegel

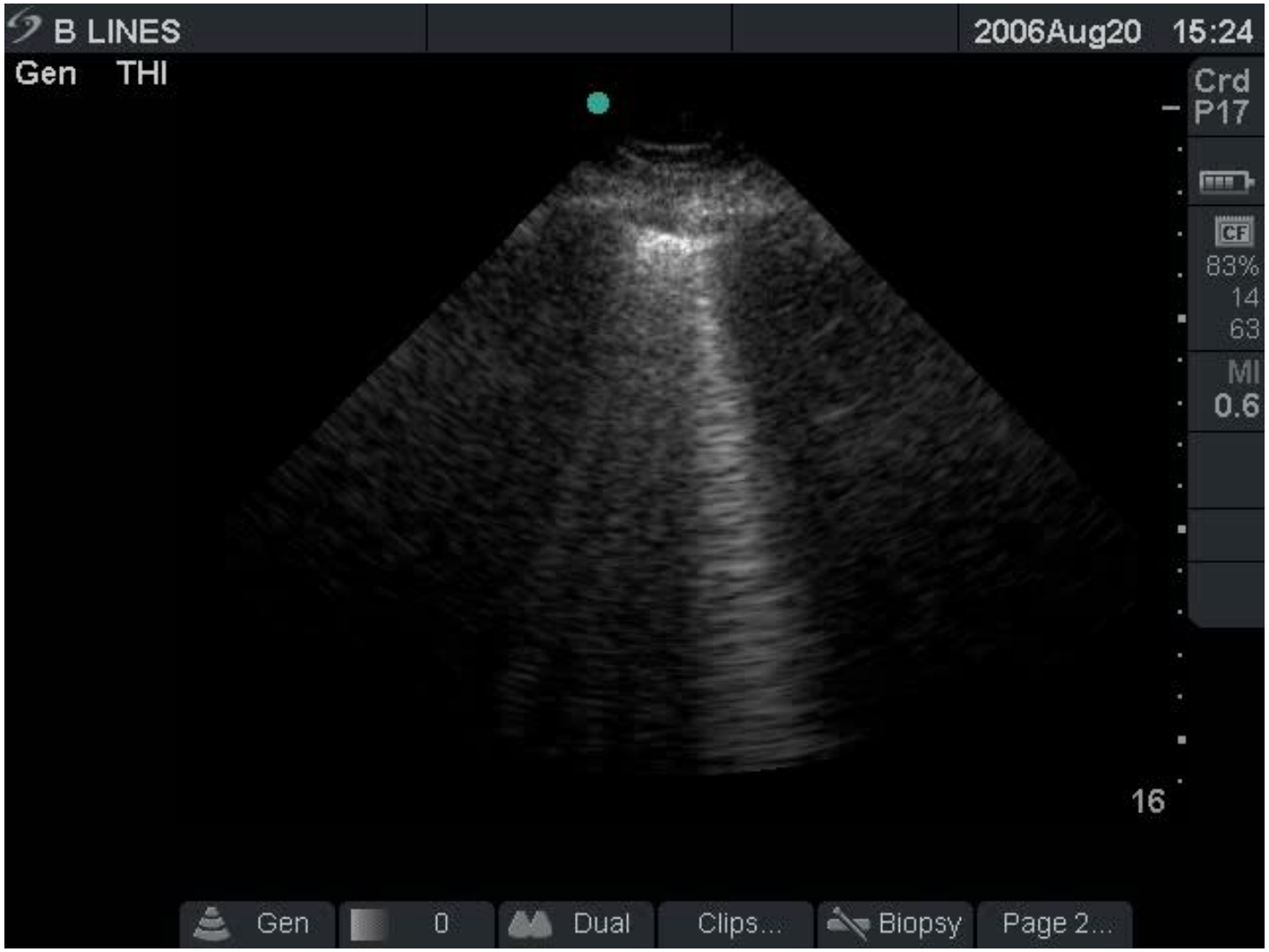


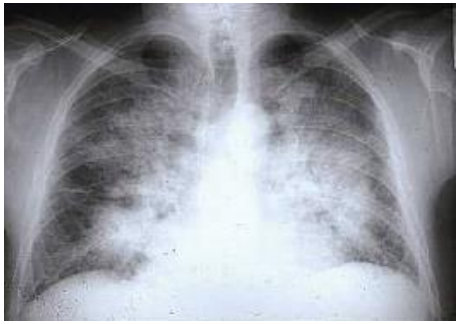


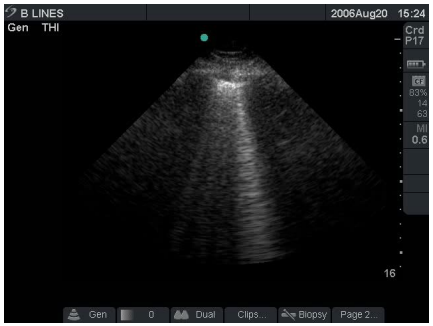
Step 2: is there a pulmonary oedema?

OAP




B LINES
2006Aug20 15:24
Gen THI
Crd
P17
CF
83%
14
63
MI
0.6
16
Gen
0
Dual
Clips...
Biopsy
Page 2...





Bilateral pneumoniae

ARDS

Hemodynamic Pulmonary oedema

Step 3 : diagnose hemodynamic pulmonary edema

Left ventricular preload

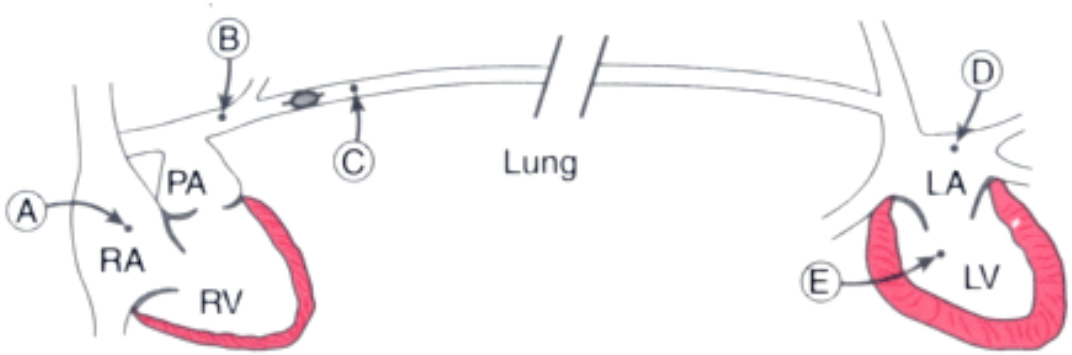
Left ventricular end diastolic pressure

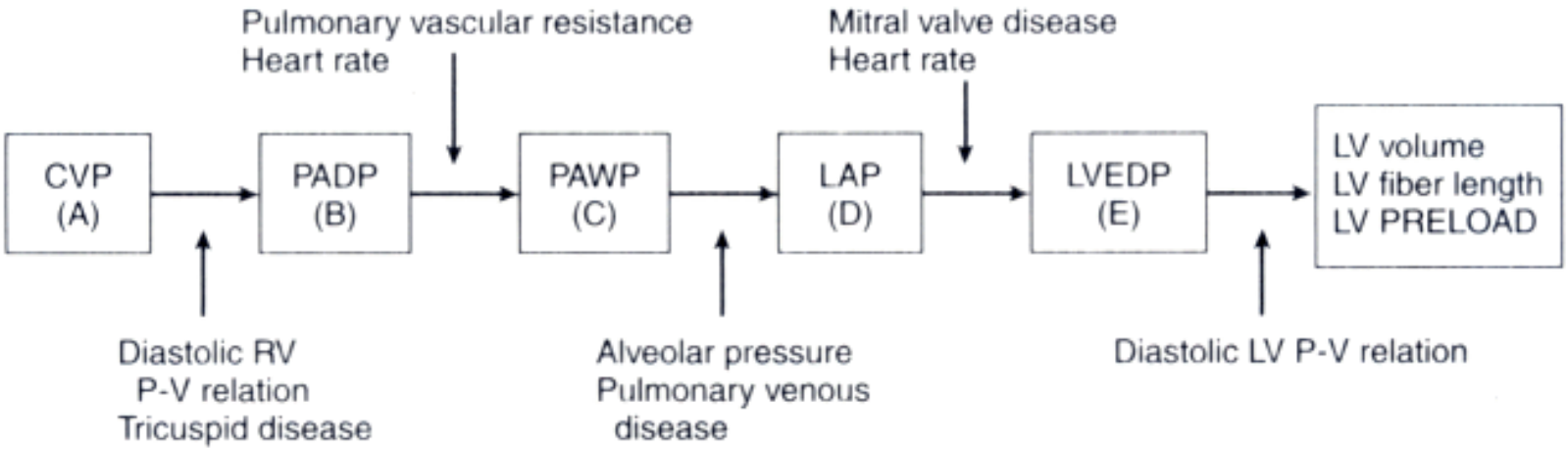
Left Ventricular Filling Pressures

Left ventricular diastolic function

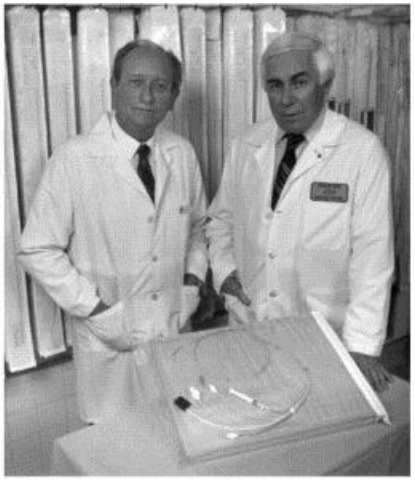
Left atrial pressure

Pulmonary artery occlusion pressure

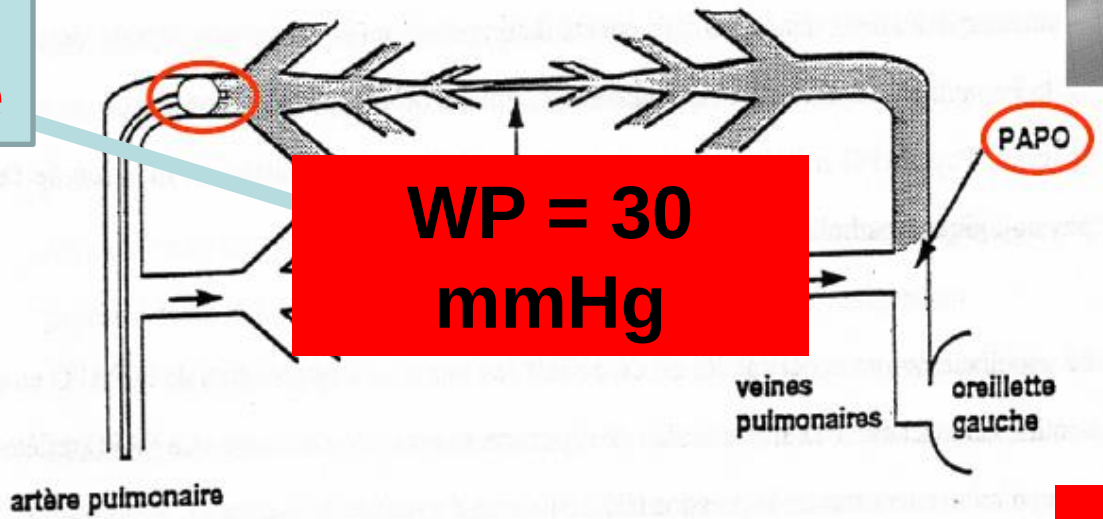

B
C
Lung
D
A
PA
LA
RA
E
LV
RV


Pulmonary vascular resistance
Heart rate
Mitral valve disease
Heart rate
CVP (A)
PADP (B)
PAWP (C)
LAP (D)
LVEDP (E)
LV volume
LV fiber length
LV PRELOAD
Diastolic RV P-V relation
Tricuspid disease
Alveolar pressure
Pulmonary venous disease
Diastolic LV P-V relation

PAOP

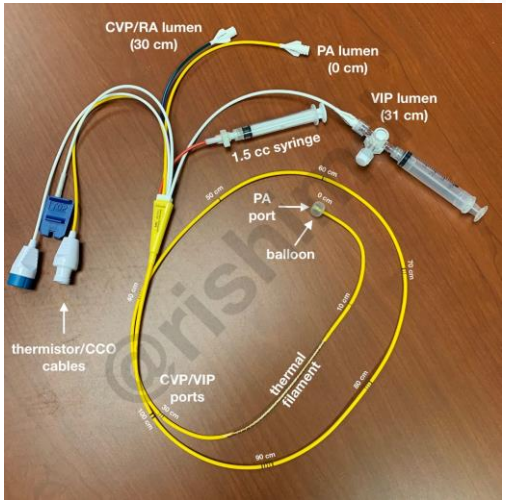


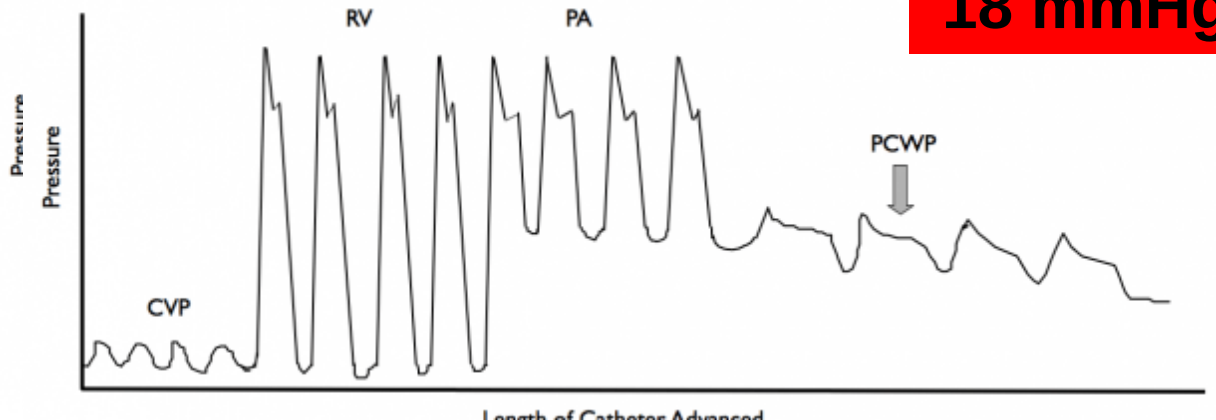
Wedge pressure

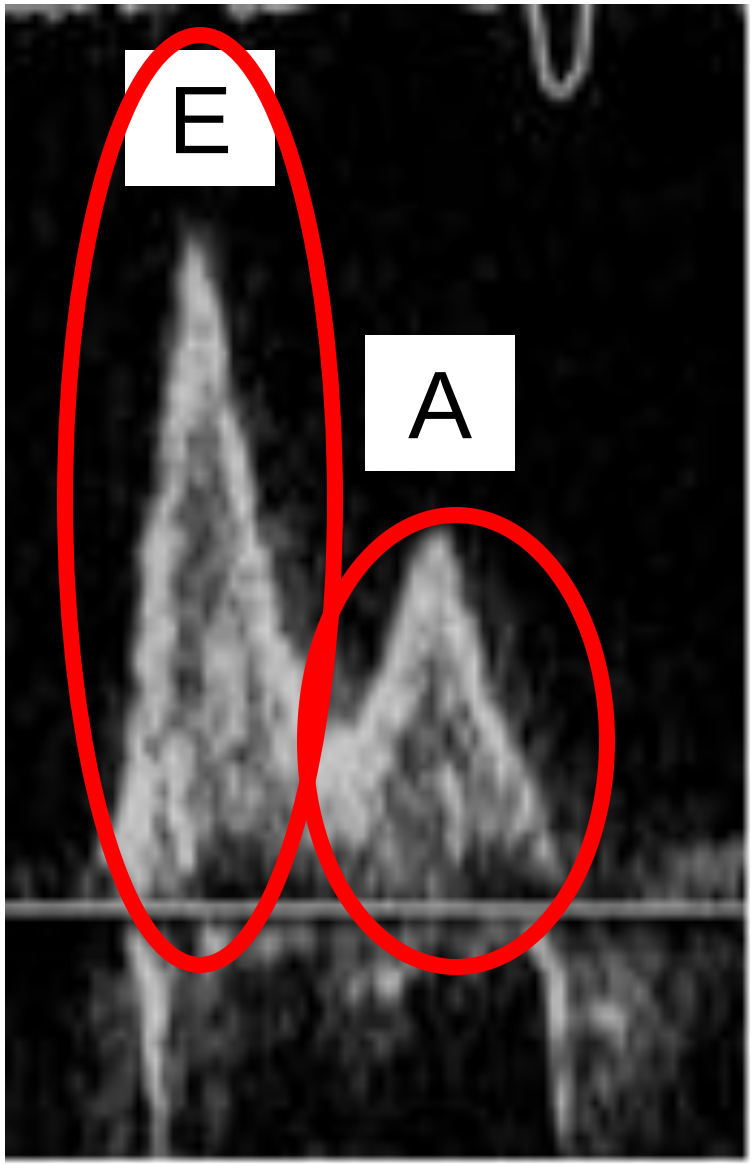


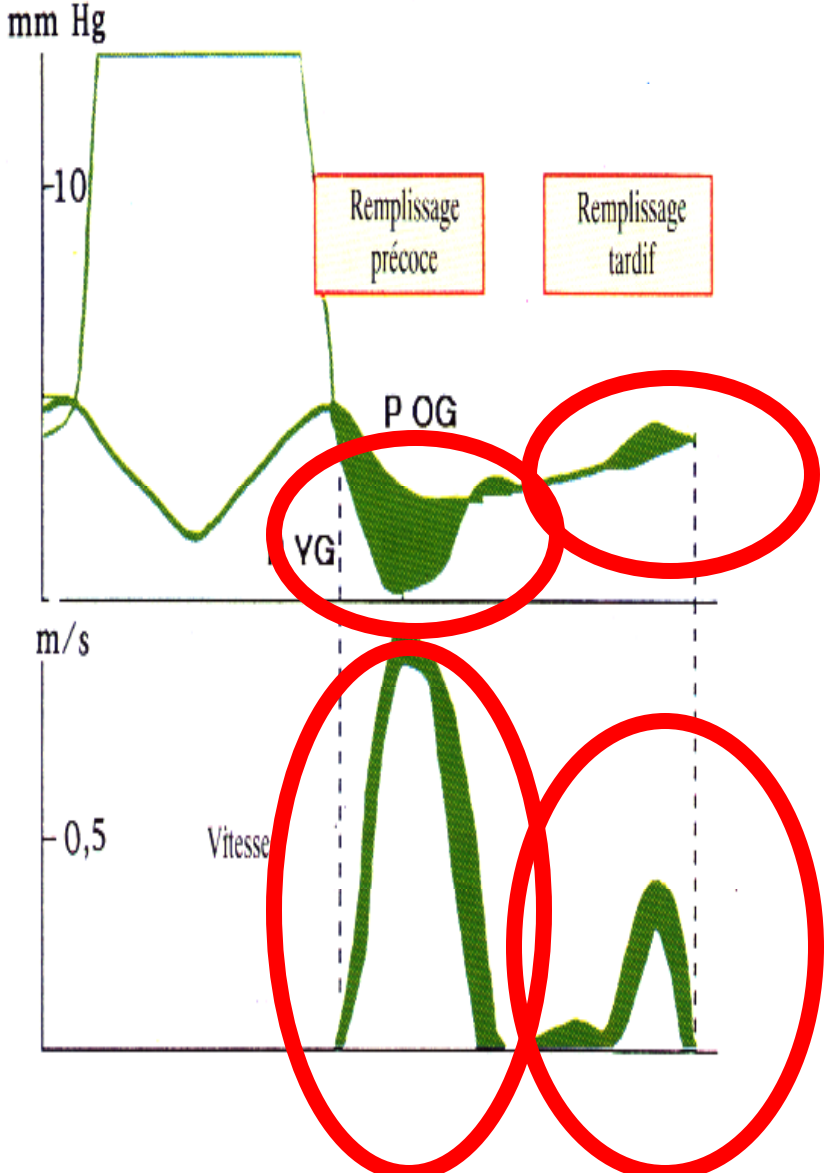
WP = 30 mmHg

PAPO = 18 mmHg

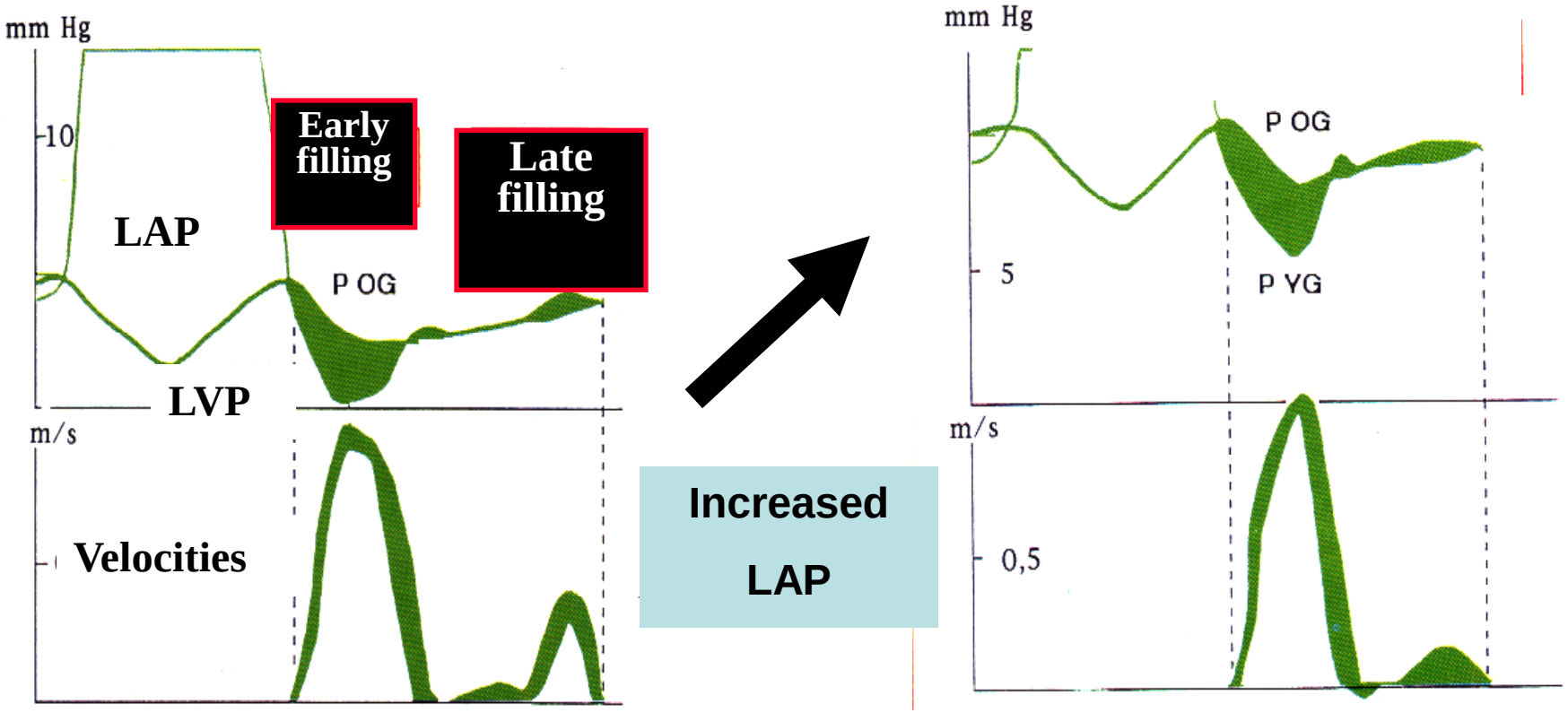




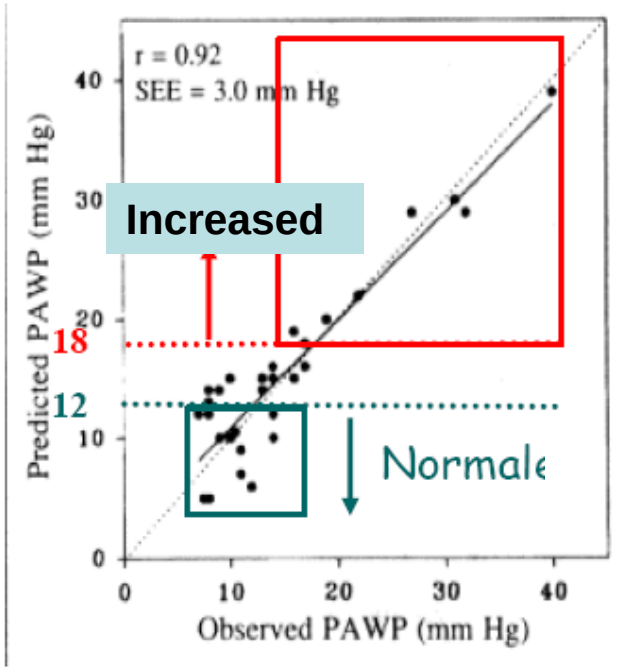

E
A


mm Hg
10
Remplissage précoce
Remplissage tardif
P OG
VG
m/s
0,5
Vitesse

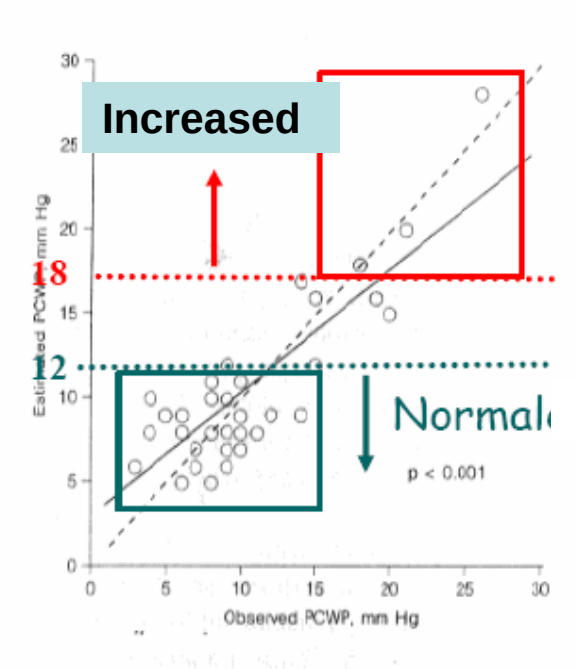
Mitral Flow


mm Hg
10
LAP
Early filling
Late filling
P OG
LVP
m/s
Velocities
Increased LAP
mm Hg
P OG
5
P YG
m/s
0,5

Evaluation of PAOP by using mitral Doppler flow



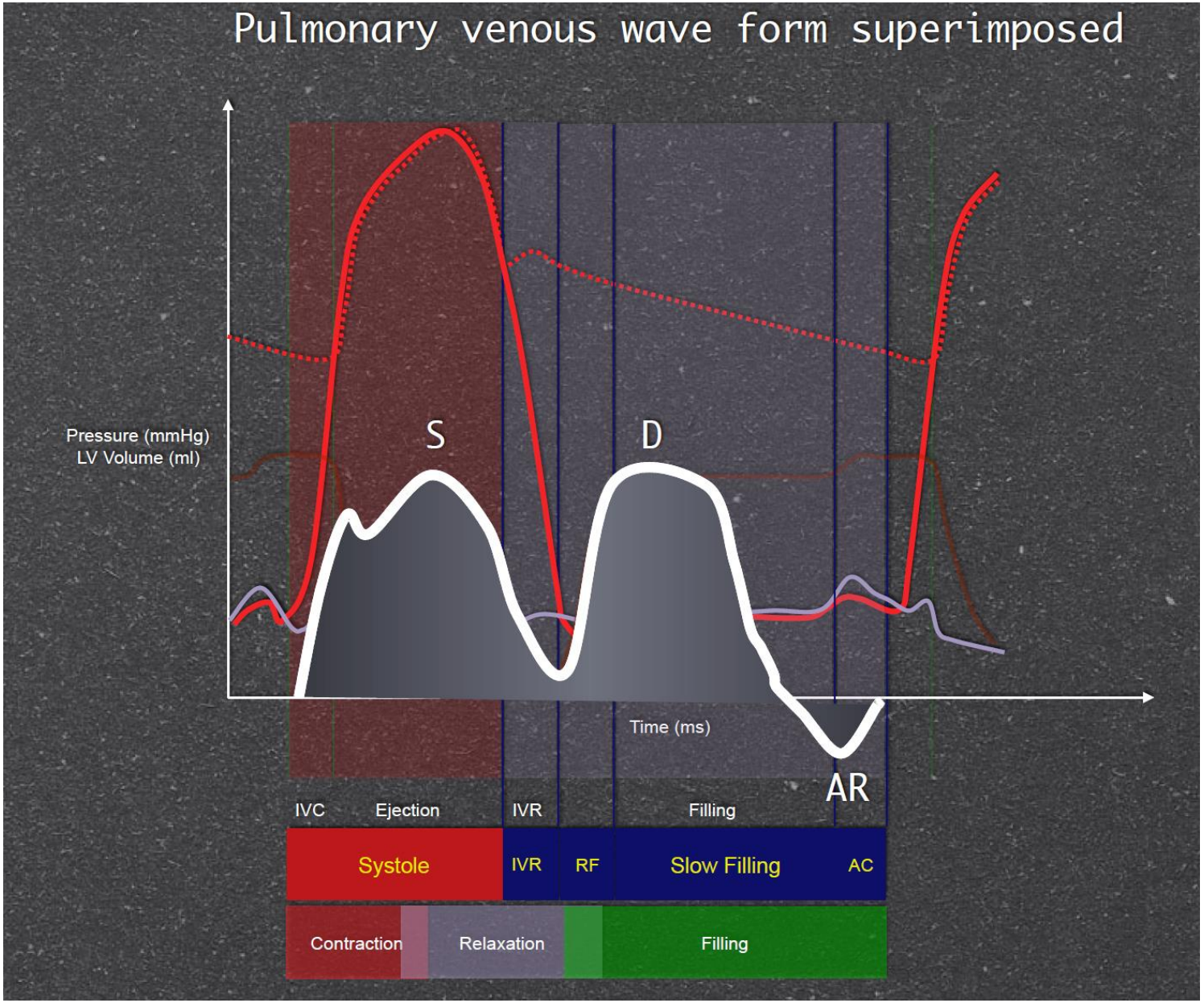
Vanoverschelde et al. *Am J Cardiol* 1995 ; 75 : 383-9



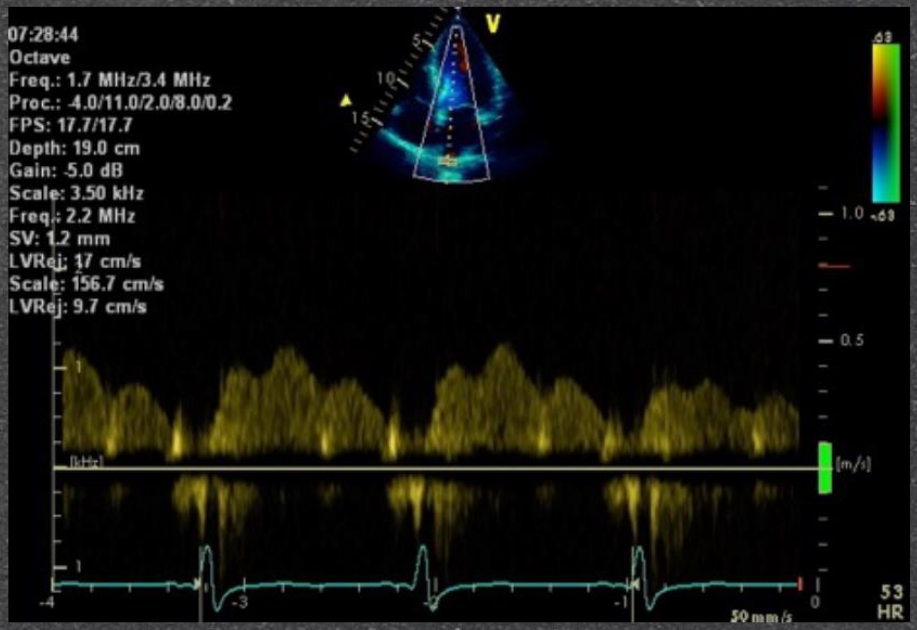
Suwa et al. *Am J Noninvas Cardiol* 1994 ; 8 : 207-14

Pulmonary venous flow

Pulmonary venous wave form superimposed



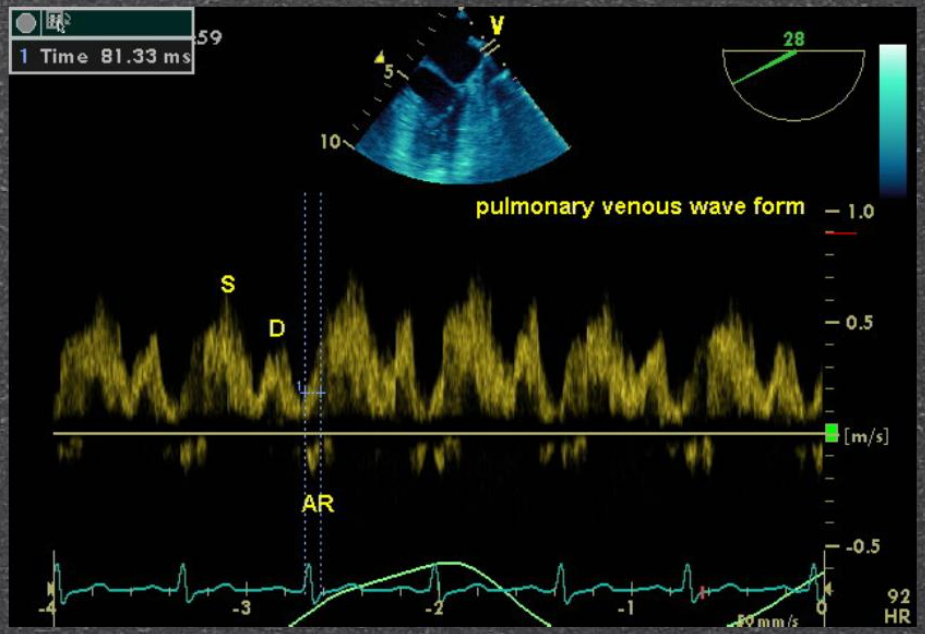
Pulmonary venous wave patterns as a guide to LAP



Systolic forward flow velocity is strongly and inversely related to LV filling pressures (exceptions eg eccentric MR)

Methods i) Systolic fraction
ii) Ar/Adur
iii) DT diastolic flow
iv) S/D ratio

Pulmonary venous wave patterns as a guide to LAP



Systolic fraction

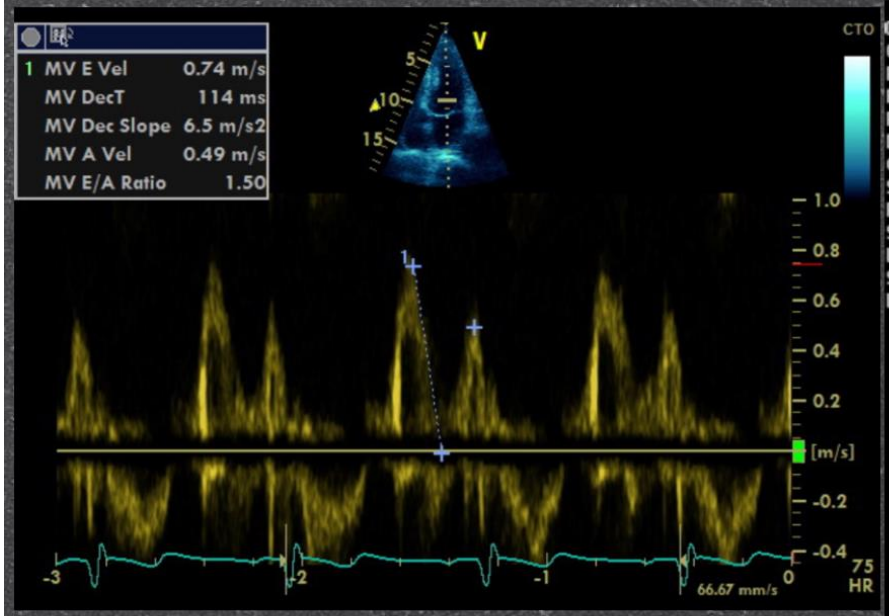
VTI systolic

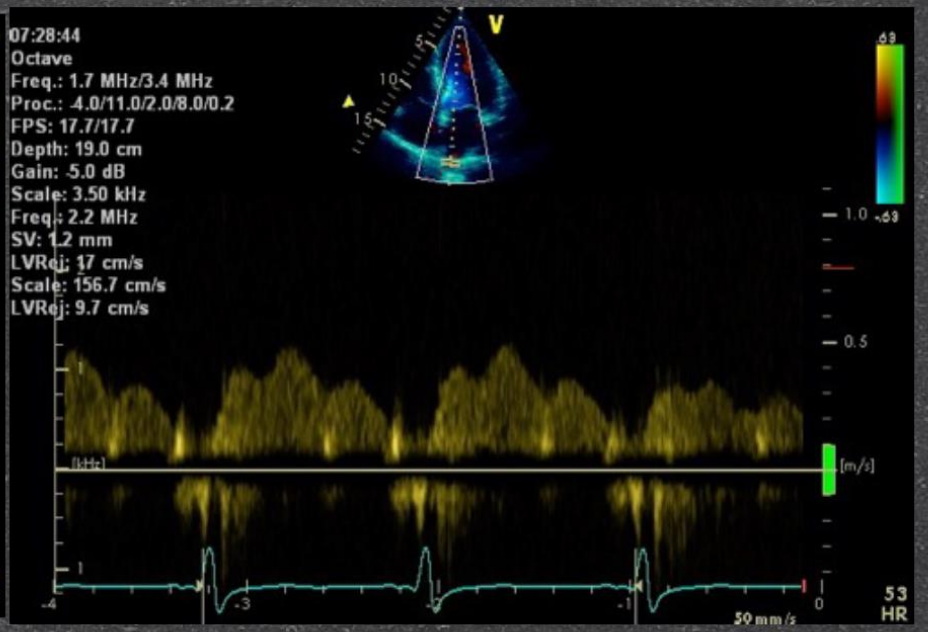
VTI systolic + diastolic < 40%

= LAP > 18 mm Hg

Kuecherer H et al Circulation 1990;82:1127

Atrial velocity & Atrial Reversal





Pulmonary Vein atrial reversal velocity

Bonita Anderson Echo 2016

Appendix 18

Sensitivities and specificities of various Doppler parameters for identifying elevated LV filling pressures

A. PV_{AR} velocity

First Author (Year)	Pt. No.	Timing of Echo & Catheterisation	LVFP (mm Hg)	Parameter & Cut-off Value	Sensitivity (%)	Specificity (%)
Cecconi (1996) [1]	101	< 24 hr	LVEDP ≥ 15	≥ 30 cm/s	82	81
			LVEDP ≥ 20	≥ 35 cm/s	55	95
Rossvoll (1993) [2]	60	< 24 hr	LVEDP > 15	≥ 35 cm/s	50	88

Abbreviations : hr = hour; **LVEDP** =left ventricular end-diastolic pressure; **LVFP** = left ventricular filling pressure; **Pt. No.** = patient number

Sources: [1] Cecconi M, Manfrin M, Zanoli R, Colonna P, Ruga O, Pangrazi A, Soro A. Doppler echocardiographic evaluation of left ventricular end-diastolic pressure in patients with coronary artery disease. *J Am Soc Echocardiogr.* 1996 May-Jun;9(3):241-50. [2] Rossvoll O, Hatle LK. Pulmonary venous flow velocities recorded by transthoracic Doppler ultrasound: relation to left ventricular diastolic pressures. *J Am Coll Cardiol.* 1993 Jun;21(7):1687-96.

Pulmonary Vein AR duration - mitral A duration

B. PV_{AR} duration – Mitral A duration

First Author (Year)	Pt. No.	Timing of Echo & Catheterisation	LVFP (mm Hg)	Parameter & Cut-off Value	Sensitivity (%)	Specificity (%)
Rossvoll (1993) [1]	60	< 24 hr	LVEDP > 15	PV_{AR} dur > A dur	85	79
Cecconi (1996) [2]	101	< 24 hr	LVEDP ≥ 15	PV_{AR} dur > A dur	79	96
			LVEDP ≥ 20	PV_{AR} dur > A dur	90	90
Ritzema (2011) [3]	15*	Simultaneous	mLAP ≥ 15	≥ 14 ms	80	82
			mLAP ≥ 20	≥ 19 ms	75	84
Appleton (1993) [4]	65	< 1 hr	LVEDP > 12	> 20 ms	74	> 95
Yamamoto (1997) [5]	83	< 3 hr	LVEDP ≥ 15	> 25 ms	46	97
			LVEDP ≥ 20	> 25 ms	71	93
Dini (2010) [6]	178	<1 hr	PCWP > 15	> 30 ms	73	80

* × 4 serial studies, n=60

mitral regurgitant velocities to measure LAP

LAP = systolic BP – MR peak pressure

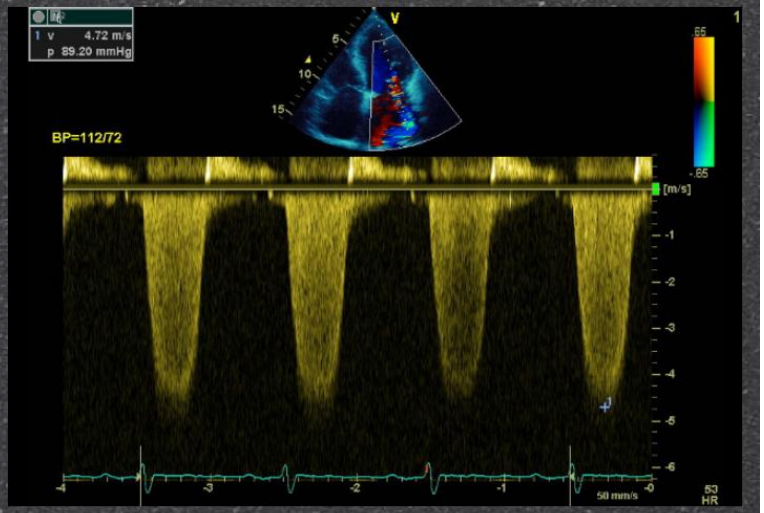
need mitral regurgitant signal

sBP in shock may not reflect LV systolic pressure

inaccurate in aortic stenosis/HOCM

often very useful

Ref: Garcia MJ et al 1997 JACC;29(2):448



ie LAP = 112 - 89 = 23 mm Hg

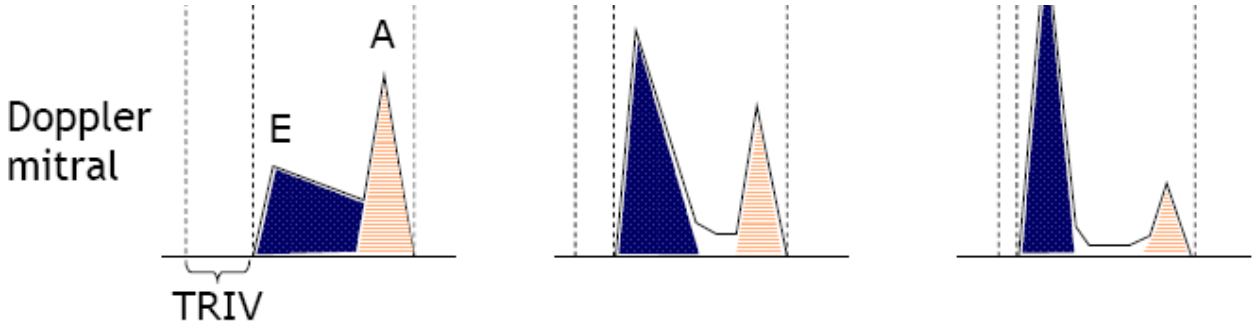
Left Ventricular Pressure

Normal

Increased

High

Left atrial pressure

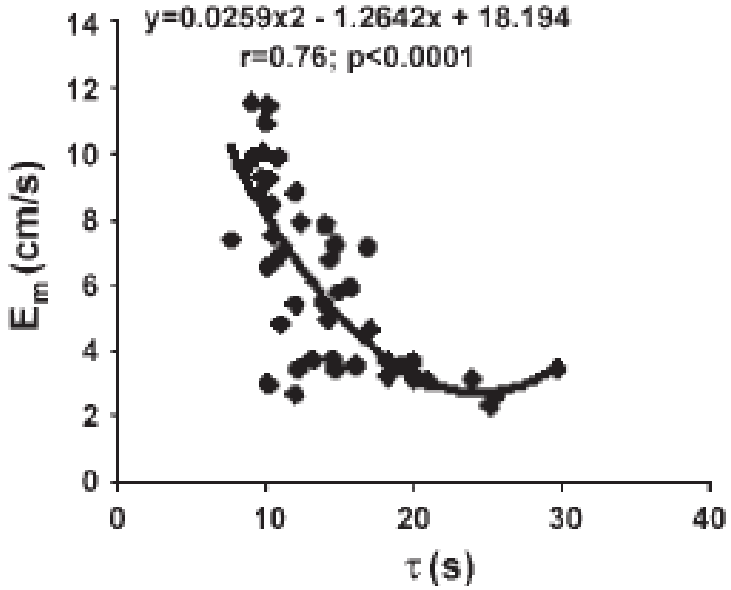


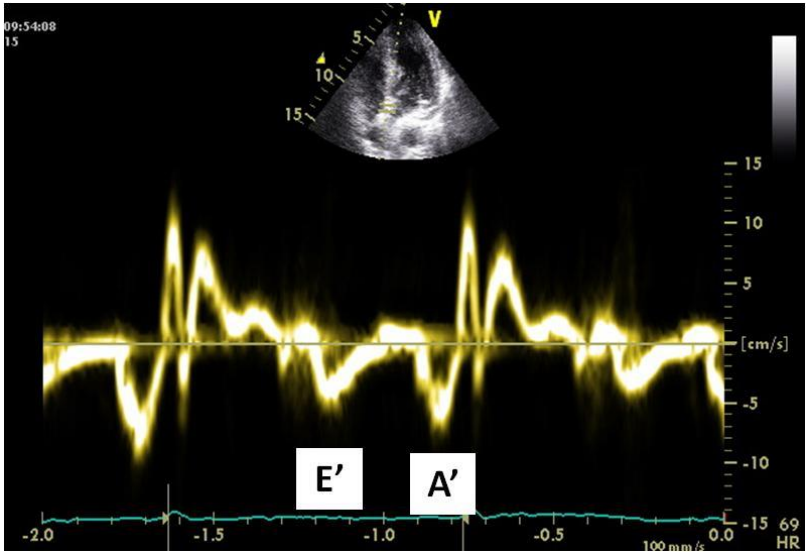
Increased PAOP

Treatment

Michel Slama, Jwari Ahn, Marcel Peltier, Julien Maizel, Denis Chemla, Jasmina Varagic, Dinko Susic, Christophe Tribouilloy and Edward D. Frohlich

Am J Physiol Heart Circ Physiol 289:1131-1136, 2005. First published Apr 29, 2005;
doi:10.1152/ajpheart.00345.2004





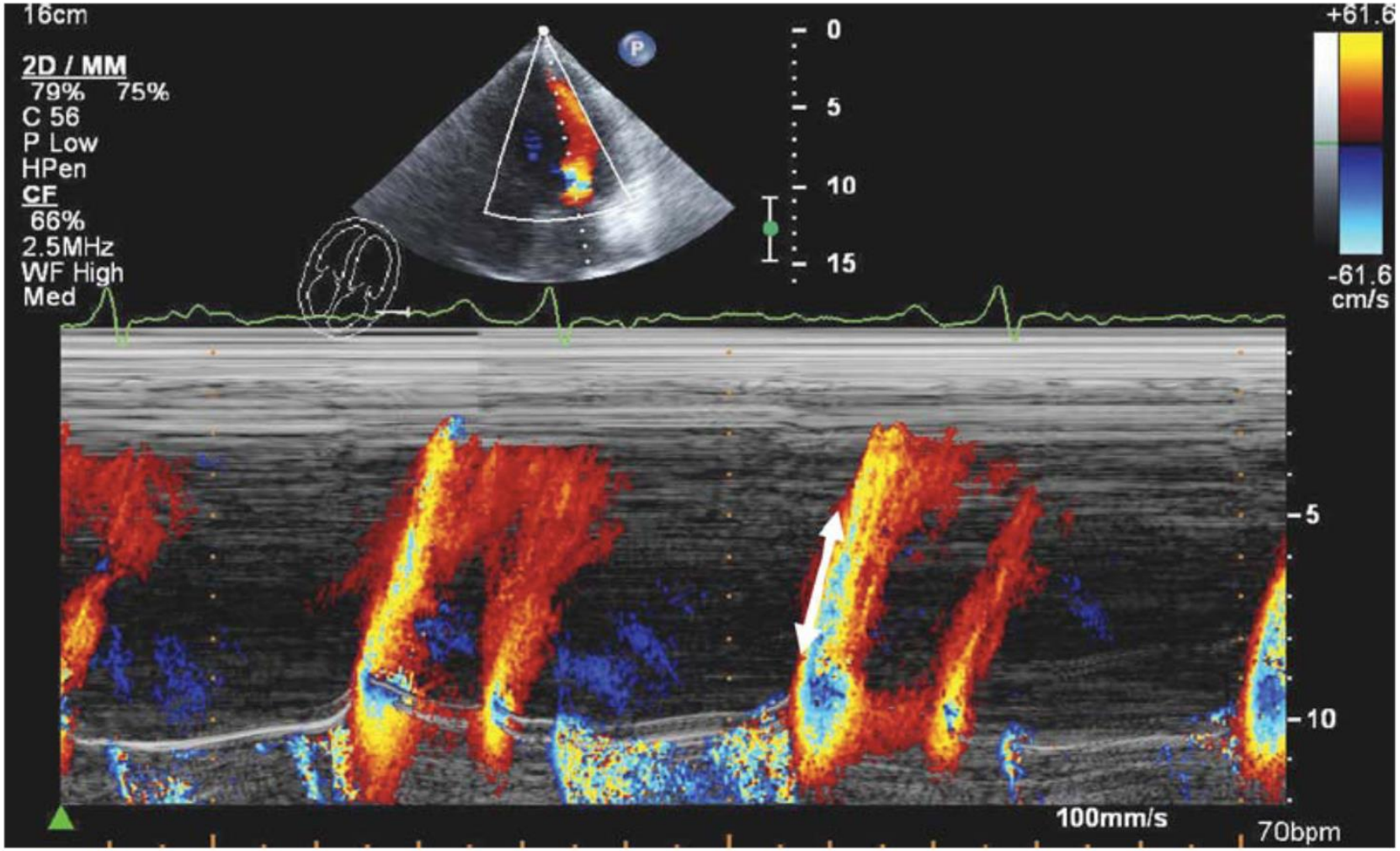
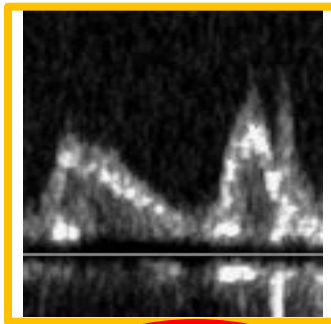


Figure 7 Color M-mode Vp from a patient with depressed EF and impaired LV relaxation. The slope *(arrow)* was 39 cm/s.



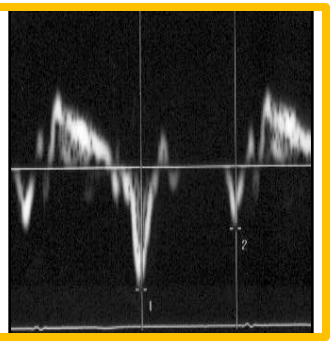
PAOP

LV relaxation

E

E’

LV relaxation



Vp

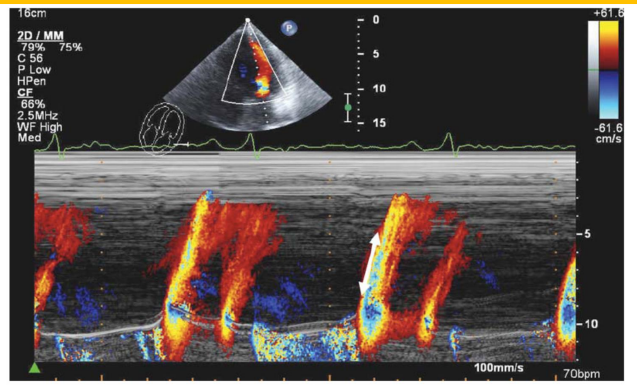
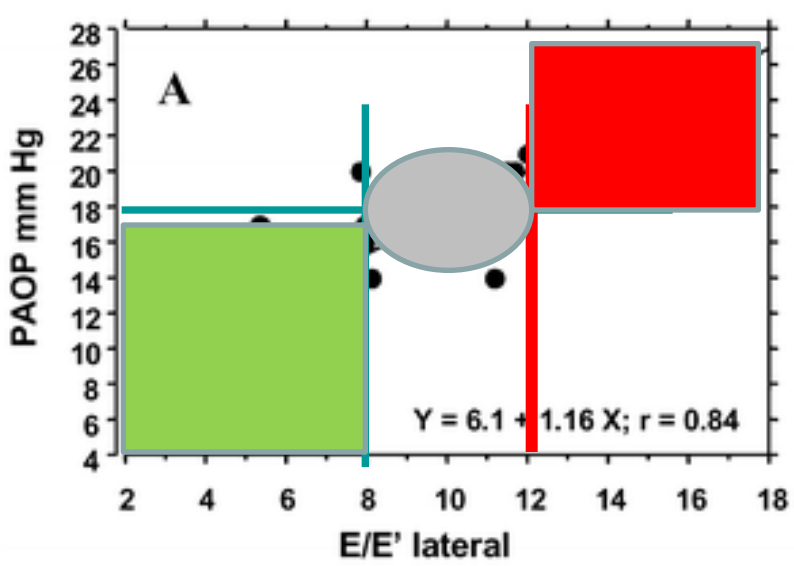
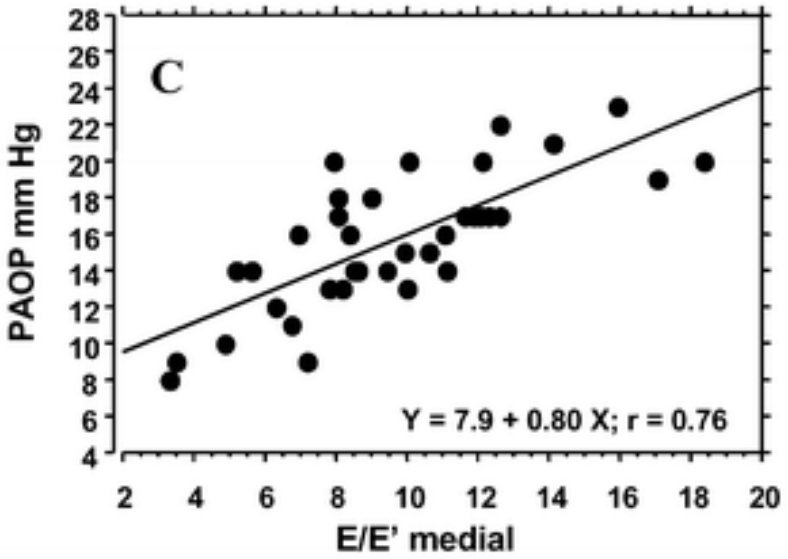
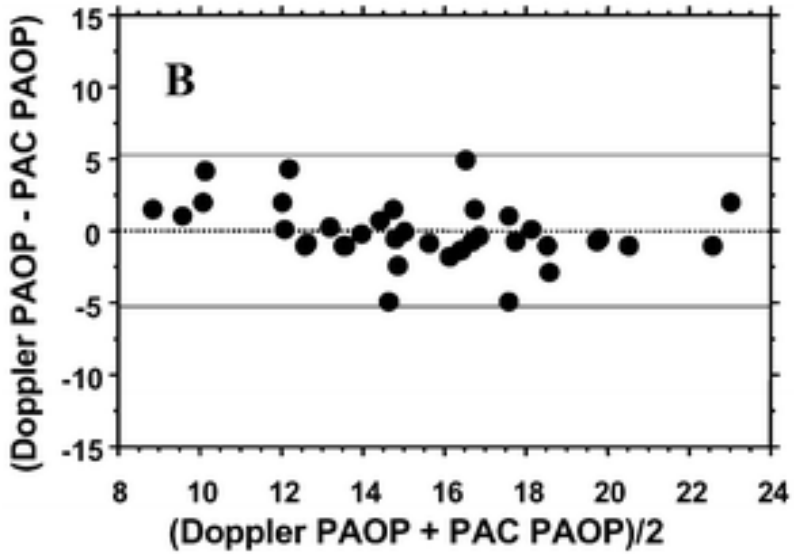


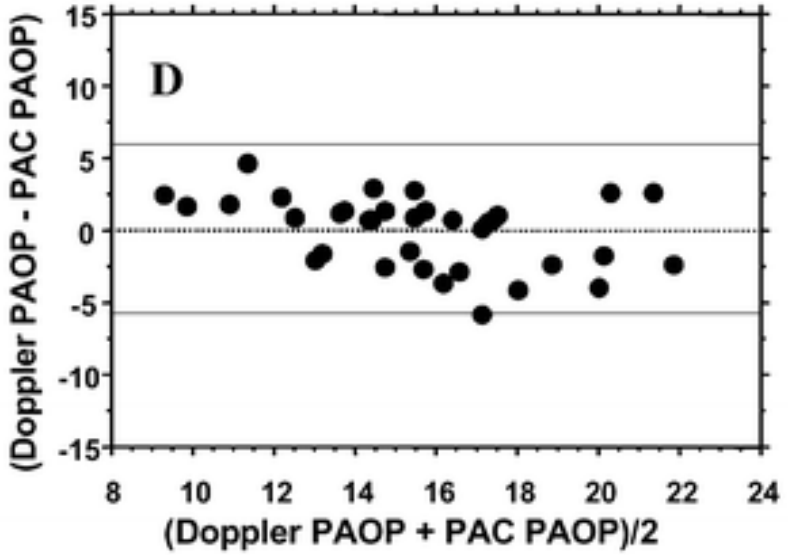
Figure 7 Color M-mode Vp from a patient with depressed EF and impaired LV relaxation. The slope *(arrow)* was 39 cm/s.

E/Ea









ICU, mechanical ventilation

Combes A Int Care Med 2004

Diagnostic Accuracy of Tissue Doppler Index E/è for Evaluating Left Ventricular Filling Pressure and Diastolic Dysfunction/Heart Failure With Preserved Ejection Fraction: A Systematic Review and Meta-Analysis

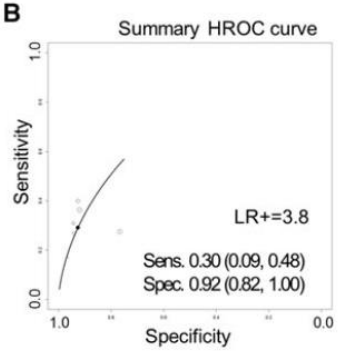
J Am Heart Assoc. 2016;

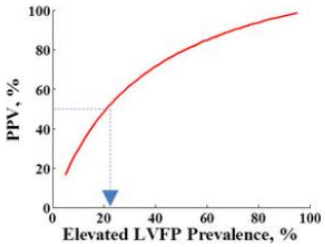
Oleg F. Sharifov, MD, PhD; Chun G. Schiros, PhD; Inmaculada Aban, PhD; Thomas S. Denney, Jr, PhD; Himanshu Gupta, MD, FACC

A

E/è Lateral >12

Study	LVFP	N	Prev. (%)	TP	FP	FN	TN	Sens. (95% CI)	Spec. (95% CI)
Kidawa, 2005* (24)	LVEDP	45/50	42	6	1	13	25	0.32 [0.15, 0.55]	0.96 [0.77, 1.00]
Ozer, 2011 (43)	LVEDP	45	51	6	1	17	21	0.26 [0.12, 0.47]	0.96 [0.74, 0.99]
Previtali, 2012* (46)	LVEDP	62/57	61	10	8	28	16	0.26 [0.15, 0.42]	0.67 [0.46, 0.82]
Rivas-Gotz, 2003* (18)	PCWP	51/55	67	15	1	20	15	0.43 [0.28, 0.59]	0.94 [0.66, 0.99]
Hadano, 2005* (23)	PCWP	63/65	19	5	4	7	47	0.42 [0.18, 0.69]	0.92 [0.81, 0.97]
Mansencal, 2004* (20)	Pre-A	20/20	25	0	0	5	15	0.08 [0.00, 0.62]	0.97 [0.65, 1.00]
Heterogeneity								I^2=0, P=0.48	I^2=63, P=0.02

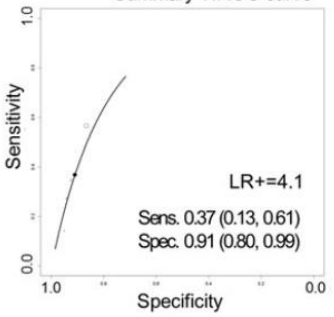


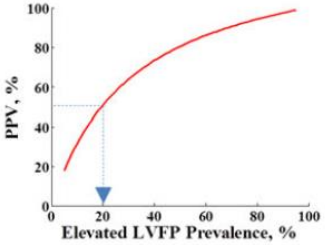


D

E/è Mean >13

Study	LVFP	N	Prev. (%)	TP	FP	FN	TN	Sens. (95% CI)	Spec. (95% CI)
Dokainish, 2010* (35)	LVEDP	122/122	81	57	3	42	20	0.58 [0.48, 0.67]	0.87 [0.66, 0.96]
Ozer, 2011 (43)	LVEDP	45	51	6	1	17	21	0.26 [0.12, 0.47]	0.96 [0.74, 0.99]
Dokainish, 2004* (19)	PCWP	19/19	58	6	2	5	6	0.54 [0.27, 0.80]	0.75 [0.38, 0.94]
Bhella, 2011* (39)	PCWP	10/10	50	3	0	2	5	0.58 [0.22, 0.88]	0.92 [0.39, 1.00]
Dini, 2010 (33)	Pre-A	55	47	9	2	17	27	0.35 [0.19, 0.54]	0.93 [0.76, 0.98]
Manouras, 2013* (48)	Pre-A	35/38	69	2	1	22	10	0.08 [0.02 ,0.28]	0.91 [0.56, 0.99]
Heterogeneity								I^2=75, P=0.001	I^2=0, P=0.70

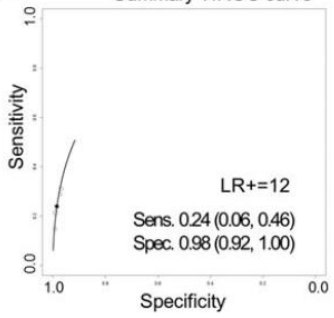


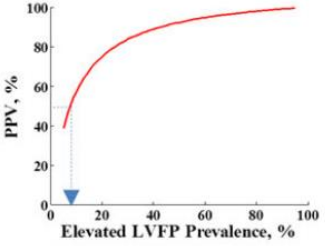


G

E/è Septal >15

Study	LVFP	N	Prev. (%)	TP	FP	FN	TN	Sens. (95% CI)	Spec. (95% CI)
Ozer, 2011 (43)	LVEDP	45	51	7	1	16	21	0.30 [0.15, 0.52]	0.96 [0.74, 0.99]
Rivas-Gotz, 2003* (18)	PCWP	52/55	69	12	1	24	15	0.33 [0.20, 0.50]	0.94 [0.66, 0.99]
Ommen, 2000* (15)	LVMDP	61/64	30	4	0	14	43	0.24 [0.10, 0.48]	0.99 [0.84, 1.00]
Rudko, 2008* (32)	LVMDP	43/39	42	2	0	16	25	0.13 [0.04, 0.36]	0.98 [0.76, 1.00]
Heterogeneity								I^2=0, P=0.45	I^2=0, P=0.74





Diagnostic Accuracy of Tissue Doppler Index E/è for Evaluating Left Ventricular Filling Pressure and Diastolic Dysfunction/Heart Failure With Preserved Ejection Fraction: A Systematic Review and Meta-Analysis

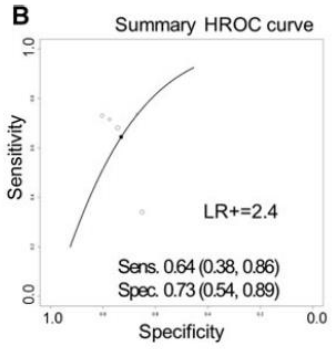
J Am Heart Assoc. 2016;

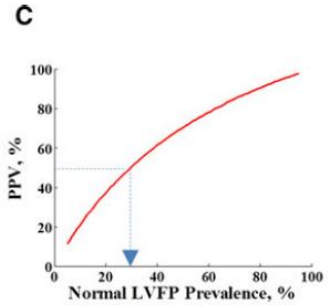
Oleg F. Sharifov, MD, PhD; Chun G. Schiros, PhD; Inmaculada Aban, PhD; Thomas S. Denney, Jr, PhD; Himanshu Gupta, MD, FACC

A

E/è Lateral <8

Study	LVFP	N	Prev. (%)	TP	FP	FN	TN	Sens. (95% CI)	Spec. (95% CI)
Kidawa, 2005* (24)	LVEDP	45/50	58	19	4	7	15	0.73 [0.53, 0.87]	0.79 [0.55, 0.92]
Previtali, 2012* (46)	LVEDP	62/57	39	6	13	18	25	0.25 [0.12, 0.46]	0.66 [0.50, 0.79]
Rivas-Gotz, 2003* (18)	PCWP	51/56	31	12	6	4	29	0.75 [0.49, 0.90]	0.83 [0.67, 0.92]
Hadano, 2005* (23)	PCWP	63/65	81	35	3	16	9	0.67 [0.55, 0.80]	0.75 [0.45, 0.92]
Mansencal, 2004* (20)	Pre-A	20/20	75	12	3	3	2	0.80 [0.53, 0.93]	0.40 [0.10, 0.80]
Heterogeneity								I^2=76, P=0.003	I^2=26, P=0.25

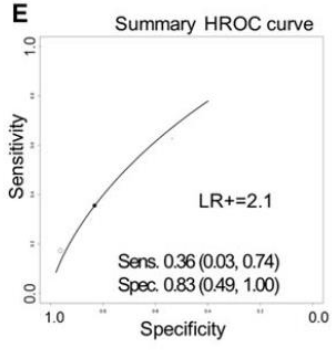


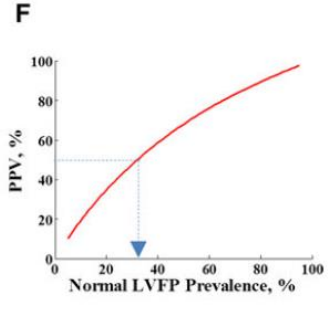


D

E/è Mean <8

Study	LVFP	N	Prev. (%)	TP	FP	FN	TN	Sens. (95% CI)	Spec. (95% CI)
Dokainish, 2010* (35)	LVEDP	122/122	19	4	3	19	96	0.17 [0.07, 0.38]	0.97 [0.91, 0.99]
Dokainish, 2004* (19)	PCWP	19/19	42	2	2	6	9	0.25 [0.06, 0.62]	0.82 [0.49, 0.95]
Bhella, 2011* (39)	PCWP	10/10	50	2	1	3	4	0.40 [0.10, 0.80]	0.80 [0.31, 0.97]
Manouras, 2013* (48)	Pre-A	35/38	31	7	12	4	12	0.64 [0.34, 0.86]	0.50 [0.31, 0.69]
Heterogeneity								I^2=56, P=0.08	I^2=87, P<0.001

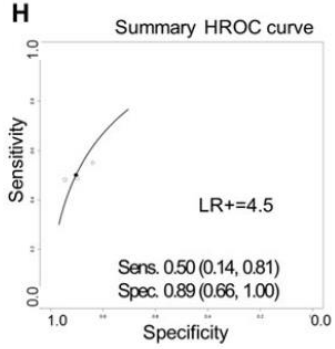


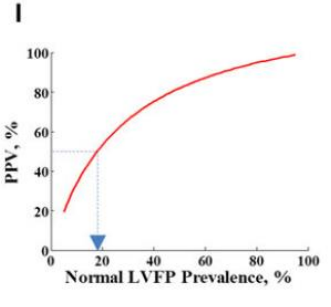


G

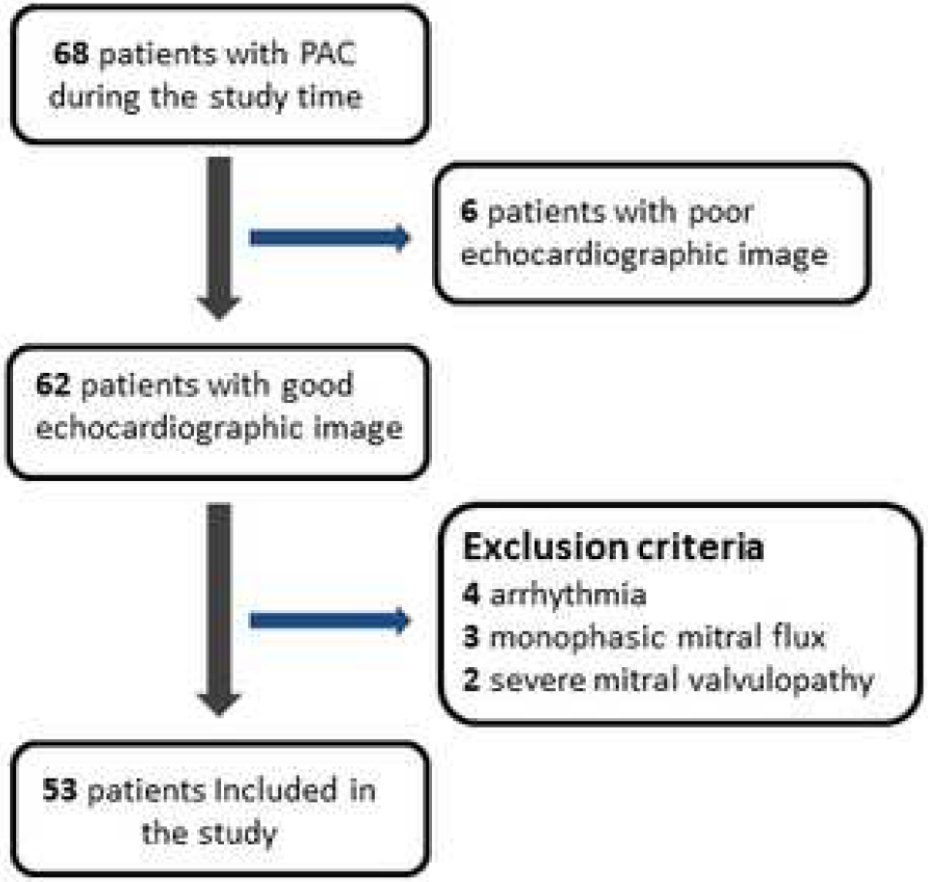
E/è Septal <8

Study	LVFP	N	Prev. (%)	TP	FP	FN	TN	Sens. (95% CI)	Spec. (95% CI)
Rivas-Gotz, 2003* (18)	PCWP	52/55	31	8	1	8	35	0.50 [0.27, 0.73]	0.97 [0.83, 1.00]
Ommen, 2000* (15)	LVMDP	61/64	70	21	2	22	16	0.49 [0.34, 0.63]	0.89 [0.65, 0.97]
Rudko, 2008* (32)	LVMDP	43/39	58	14	4	11	14	0.56 [0.37, 0.74]	0.78 [0.54, 0.91]
Heterogeneity								I^2=0, P=0.859	I^2=50, P=0.13



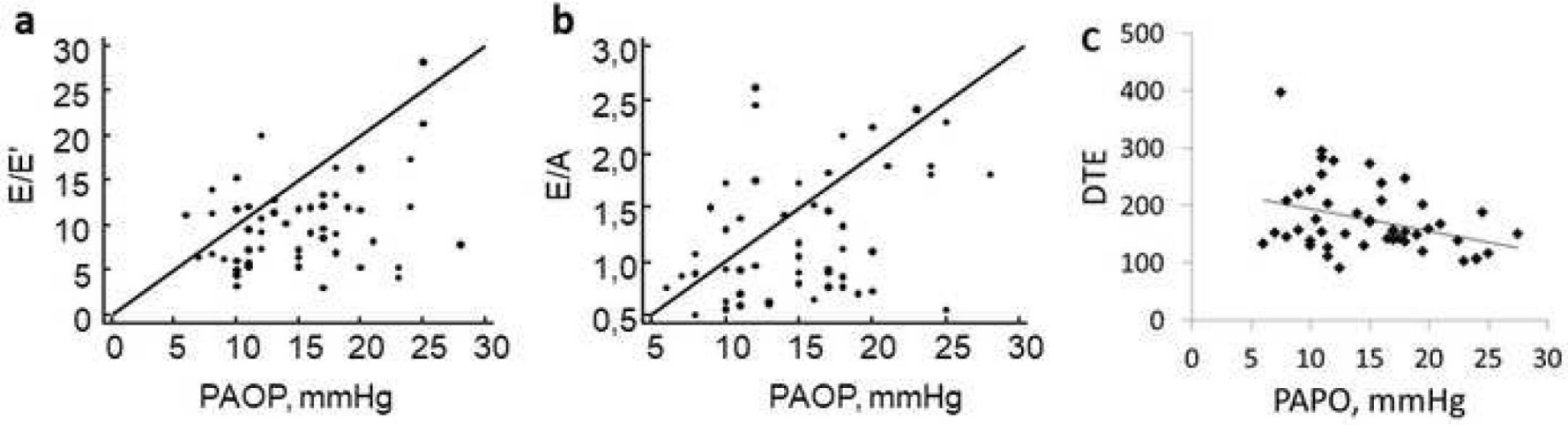


Study flow chart

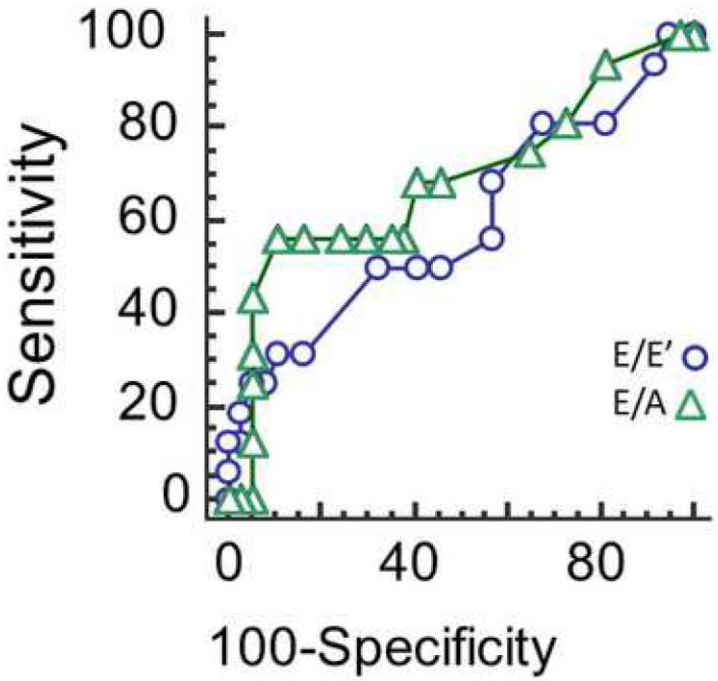


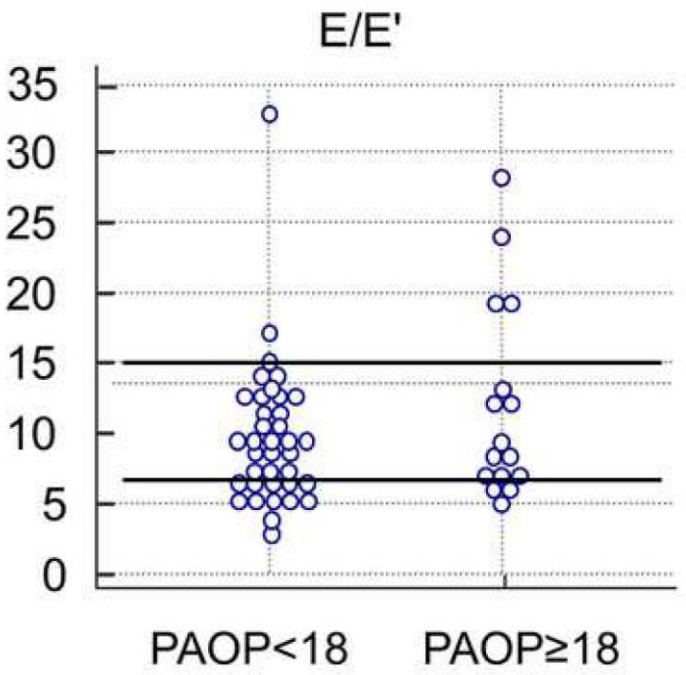
Mercado Slama CCM 2020

Classical indices fail to predict PAOP in ICU patients



Mercado Slama CCM 2020



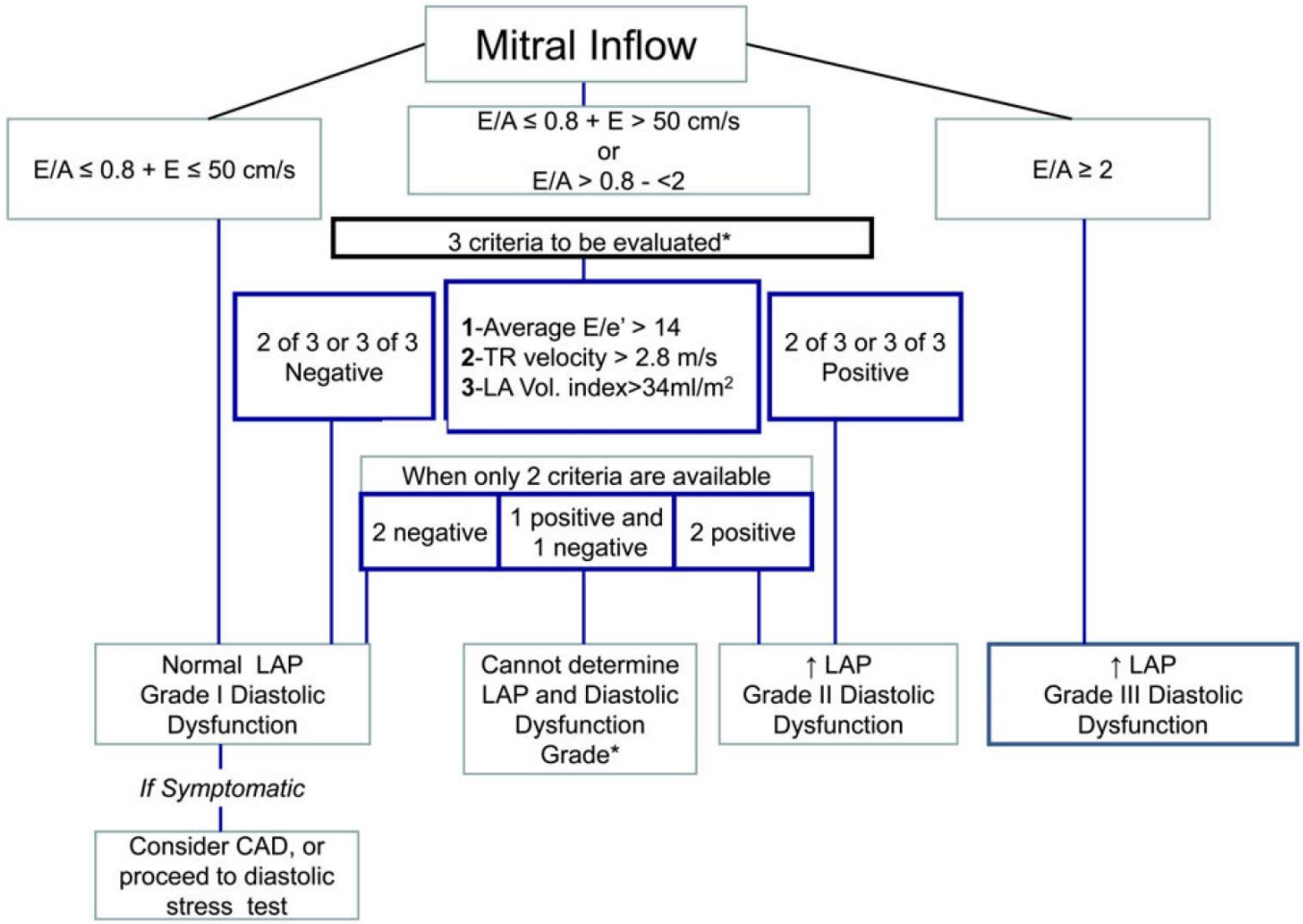


Mercado Slama CCM 2020

European Heart Journal – Cardiovascular Imaging (2016) **17**, 1321–1360
doi:10.1093/ehjci/jew082

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

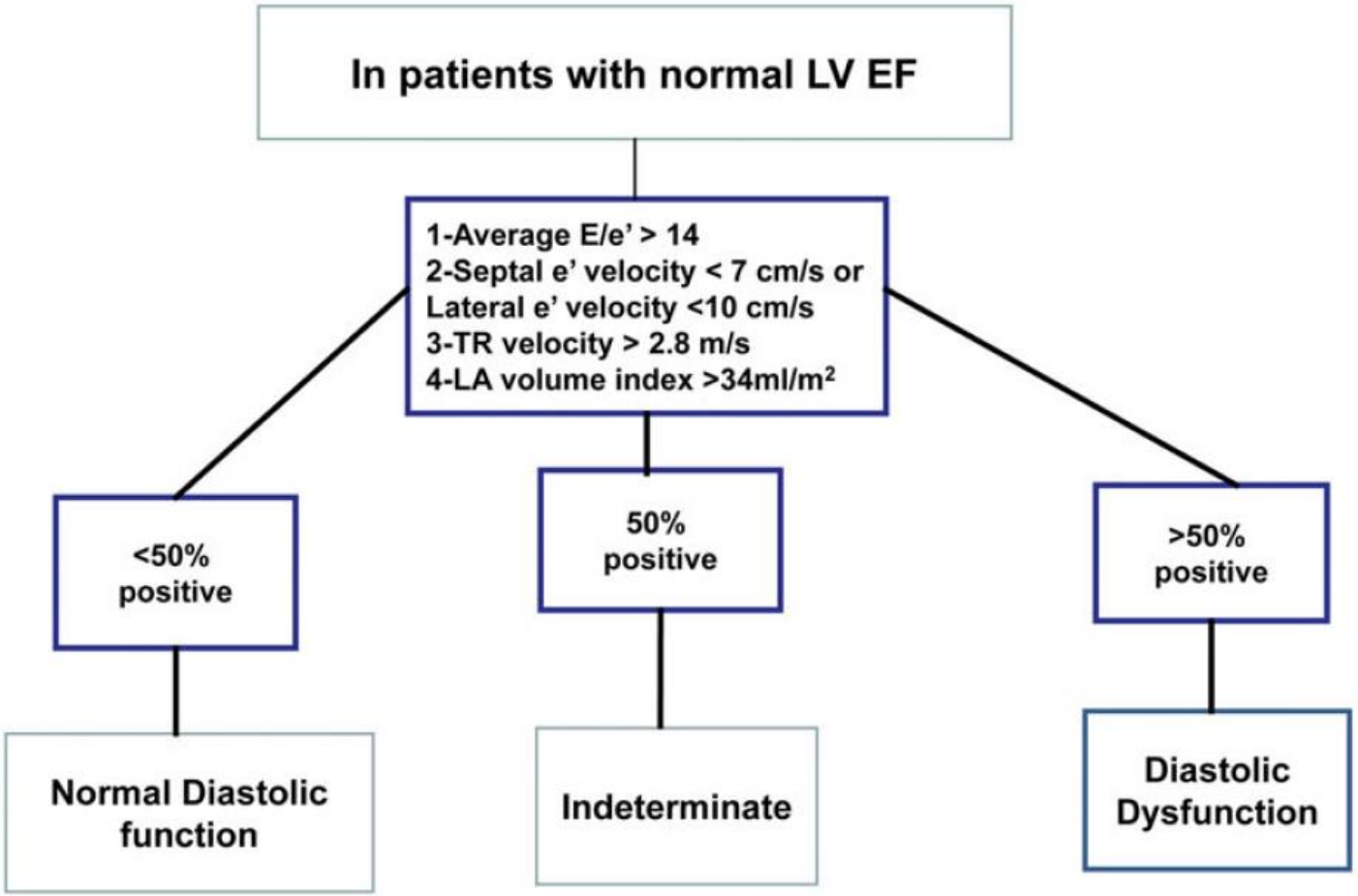
B

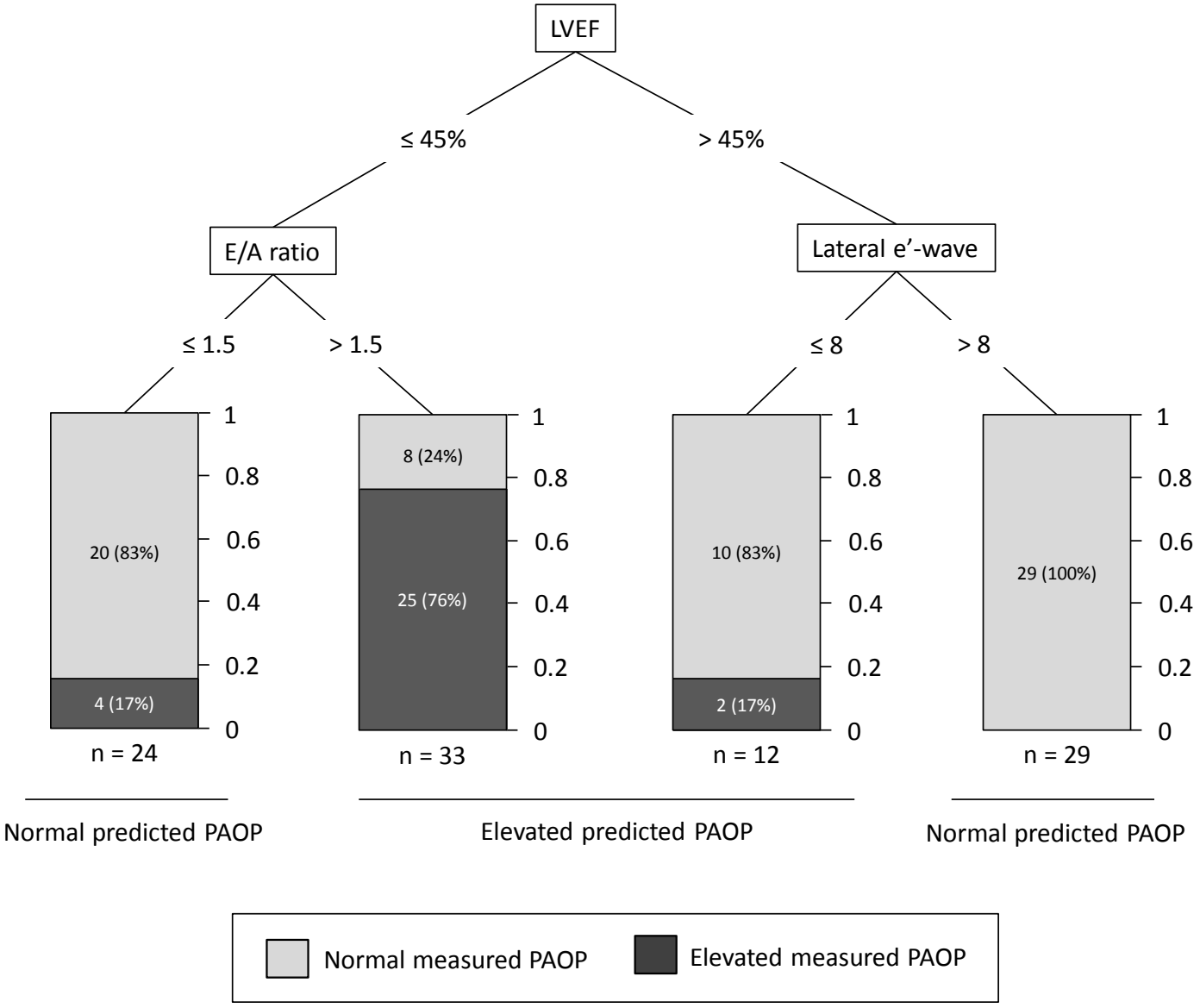


European Heart Journal – Cardiovascular Imaging (2016) **17**, 1321–1360
doi:10.1093/ehjci/jew082

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

A





Brault Slama CCM 2021

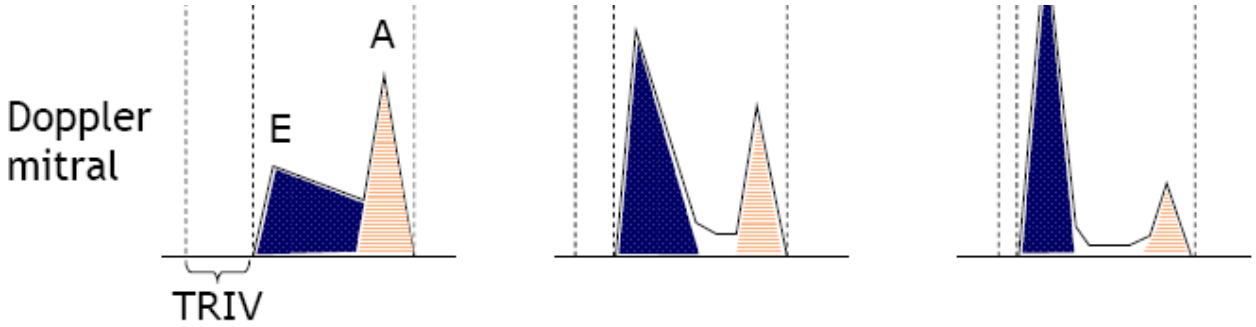
Left Ventricular Pressure

Normal

Increased

High

Left atrial pressure

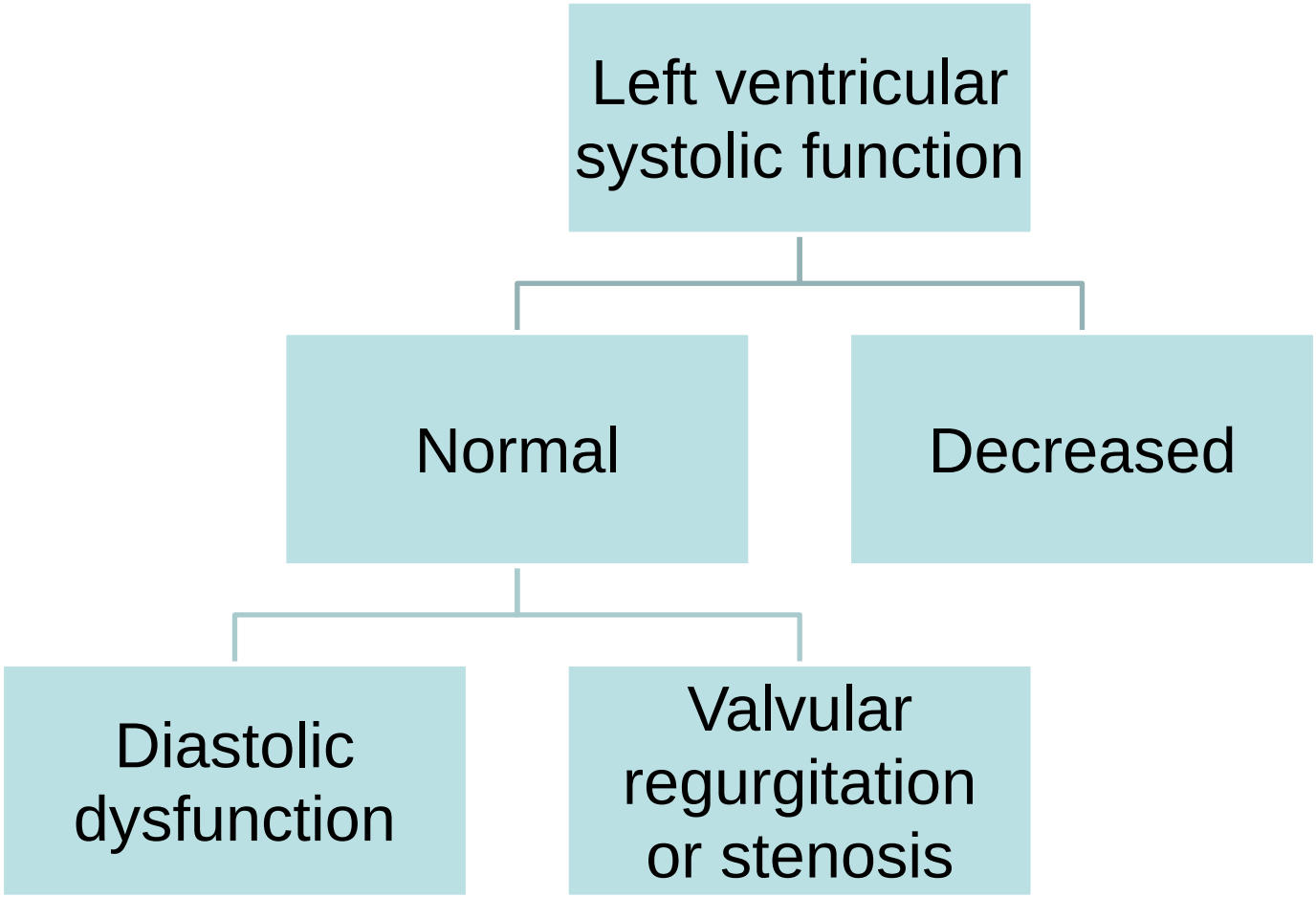


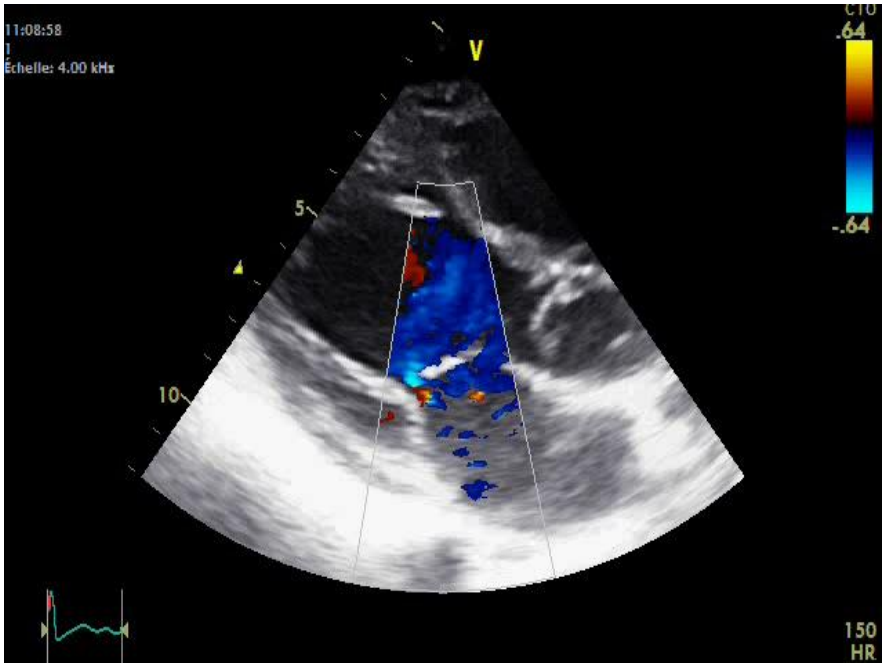
Increased PAOP

Treatment

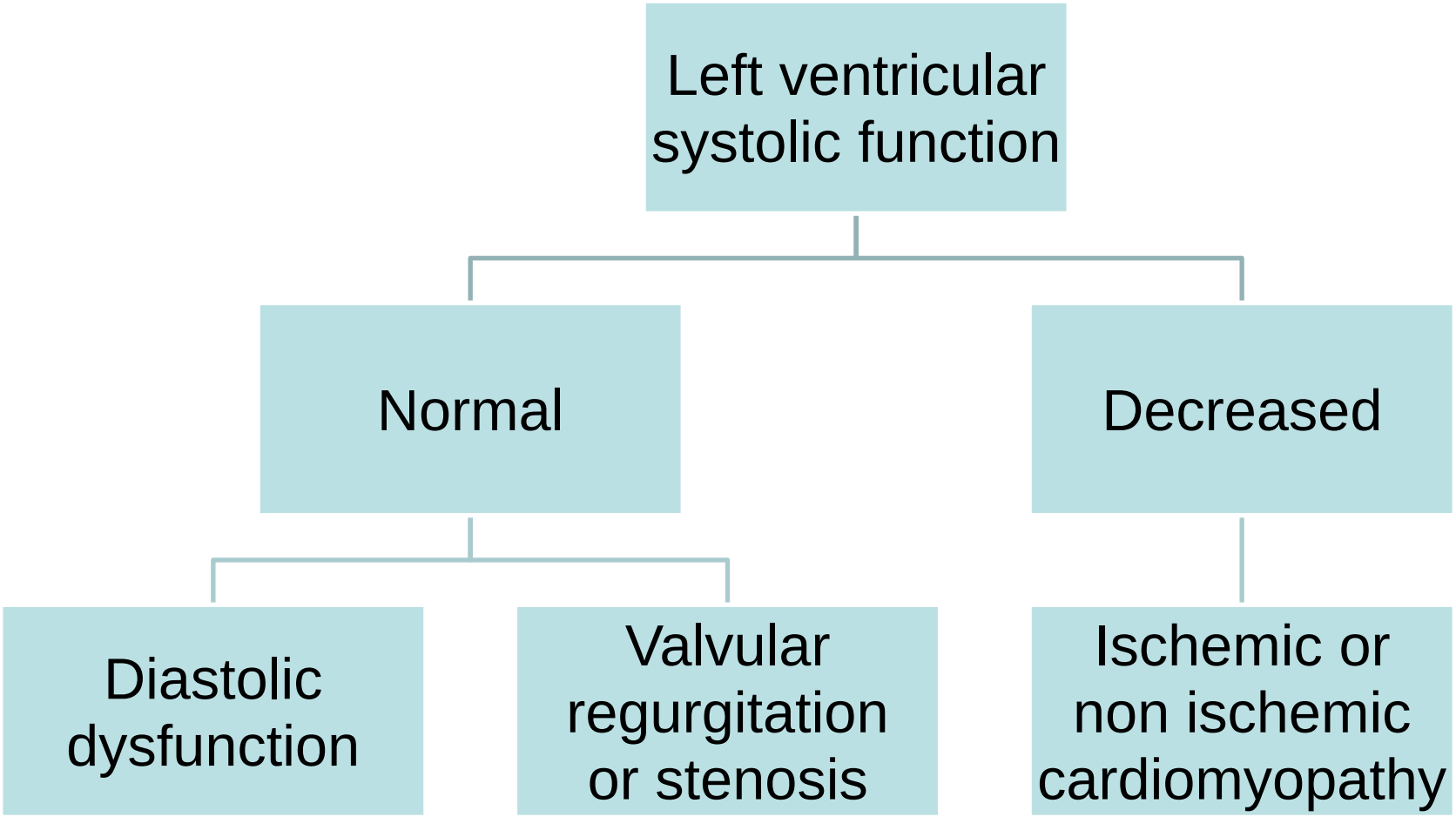
Step 4: find the cause of hemodynamic pulmonary edema

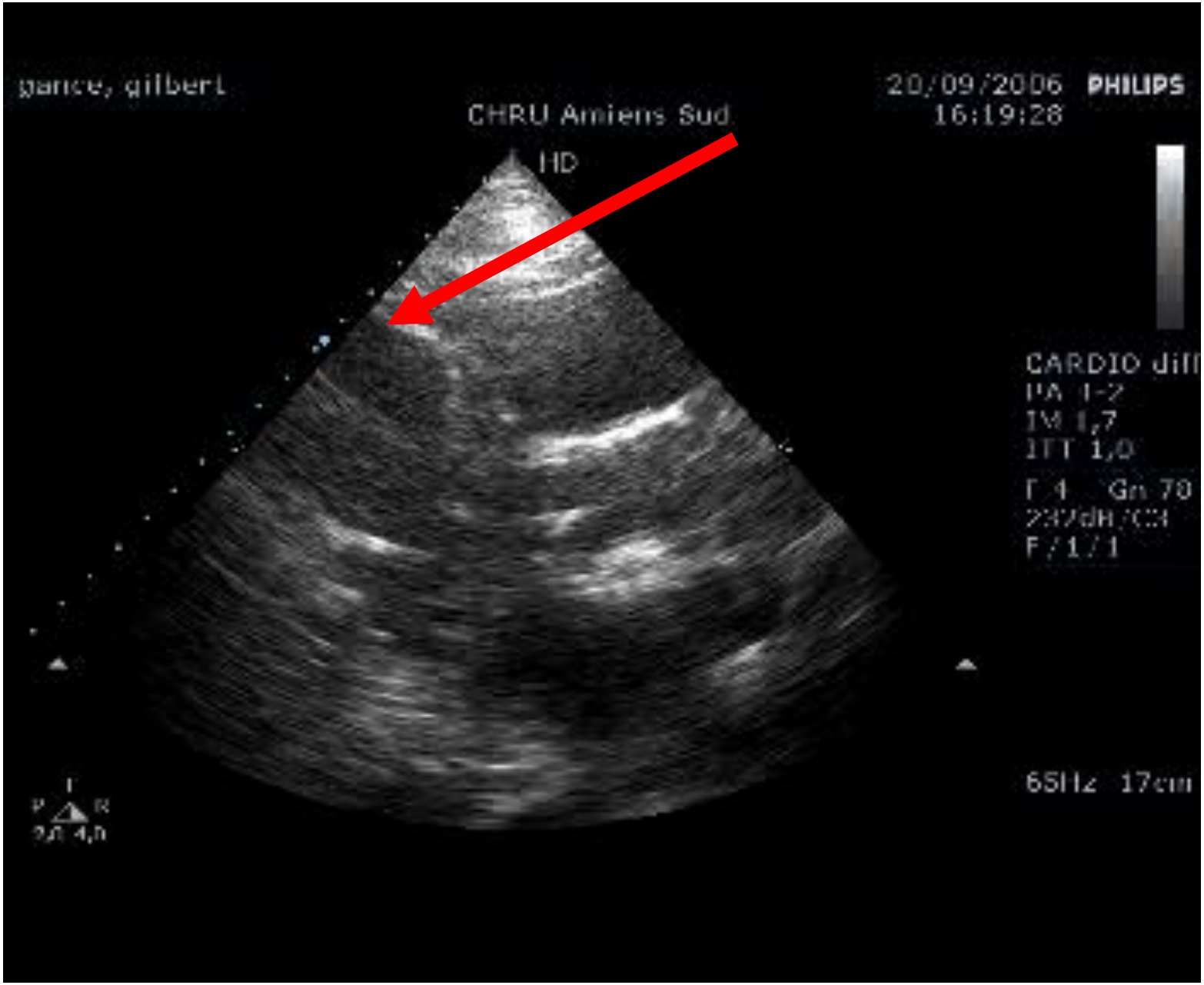
Cause of pulmonary edema

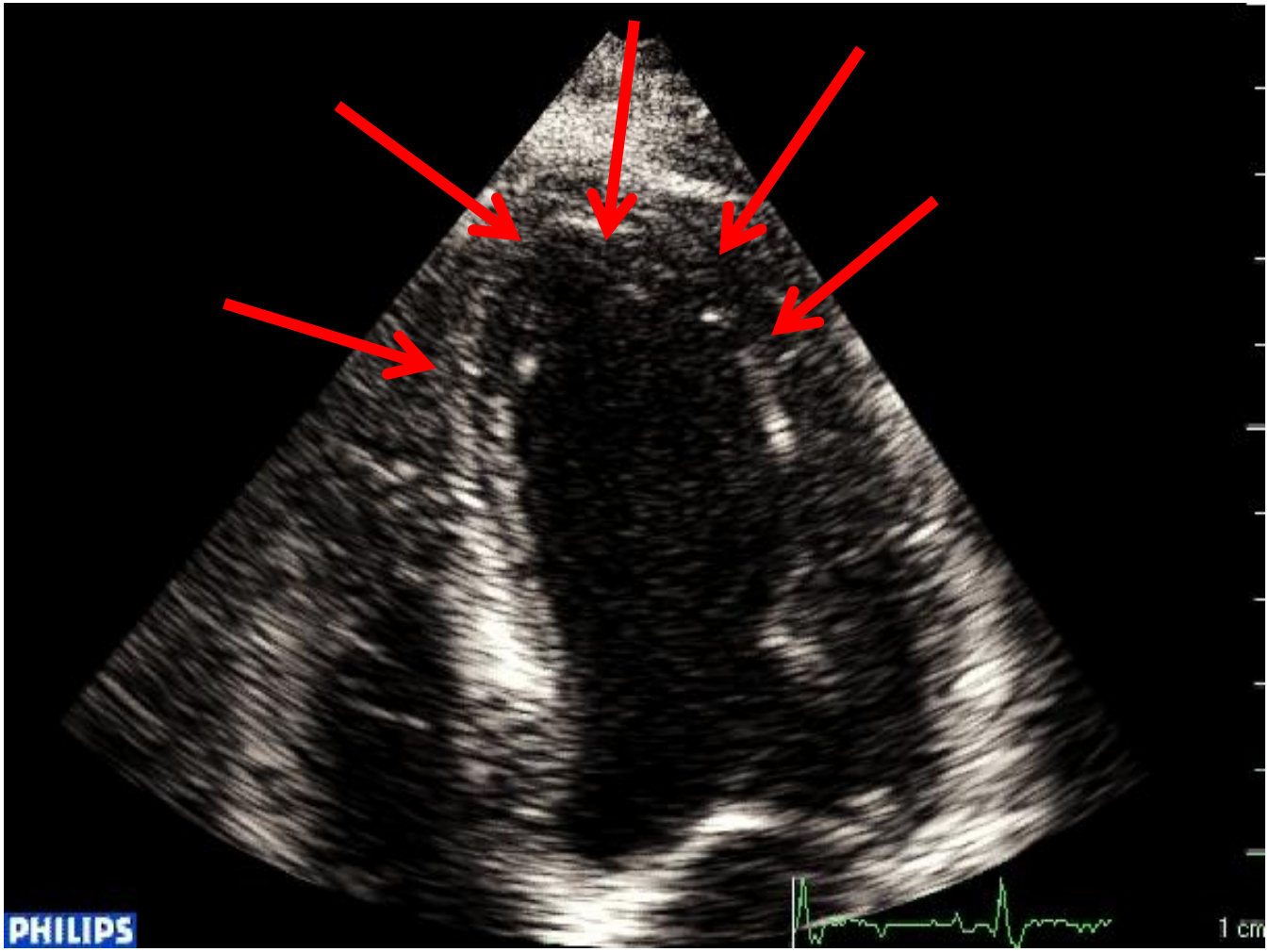



11:08:58
Échelle: 4.00 kHz
V
5
10
.64
-.64
150
HR

Cause of pulmonary edema

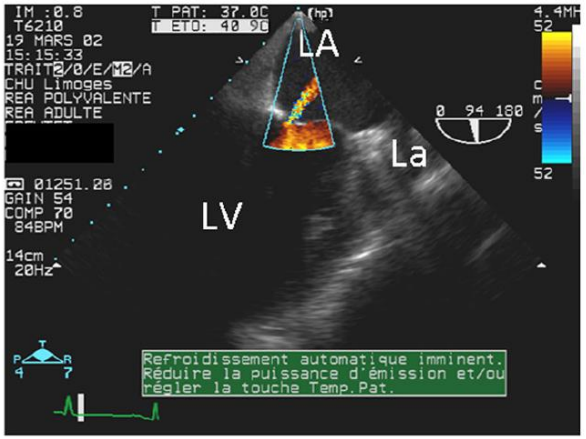


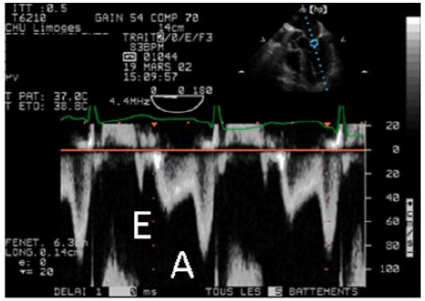

pance, gilbert
CHRU Amiens Sud
HD
20/09/2006
16:19:28
PHILIPS
CARDIO diff
PA 1-2
IM 1,7
ITT 1,0
Gn 70
F/1/1
65Hz 17cm

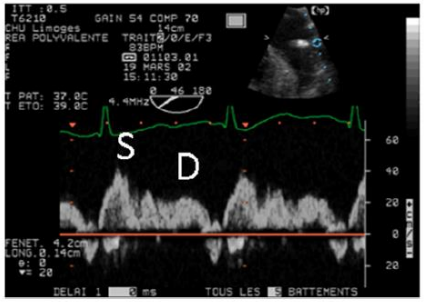

PHILIPS
1 cm

Le plus important en réanimation c'est le suivi

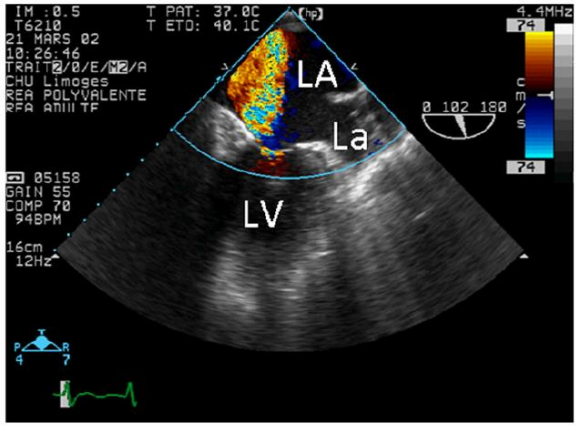
Pressure support

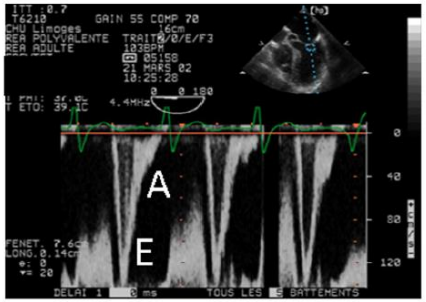


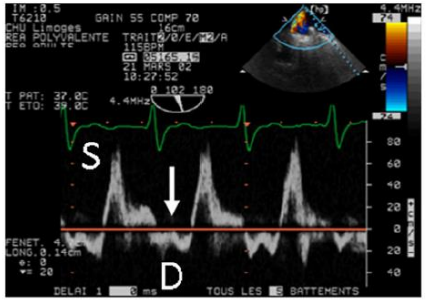




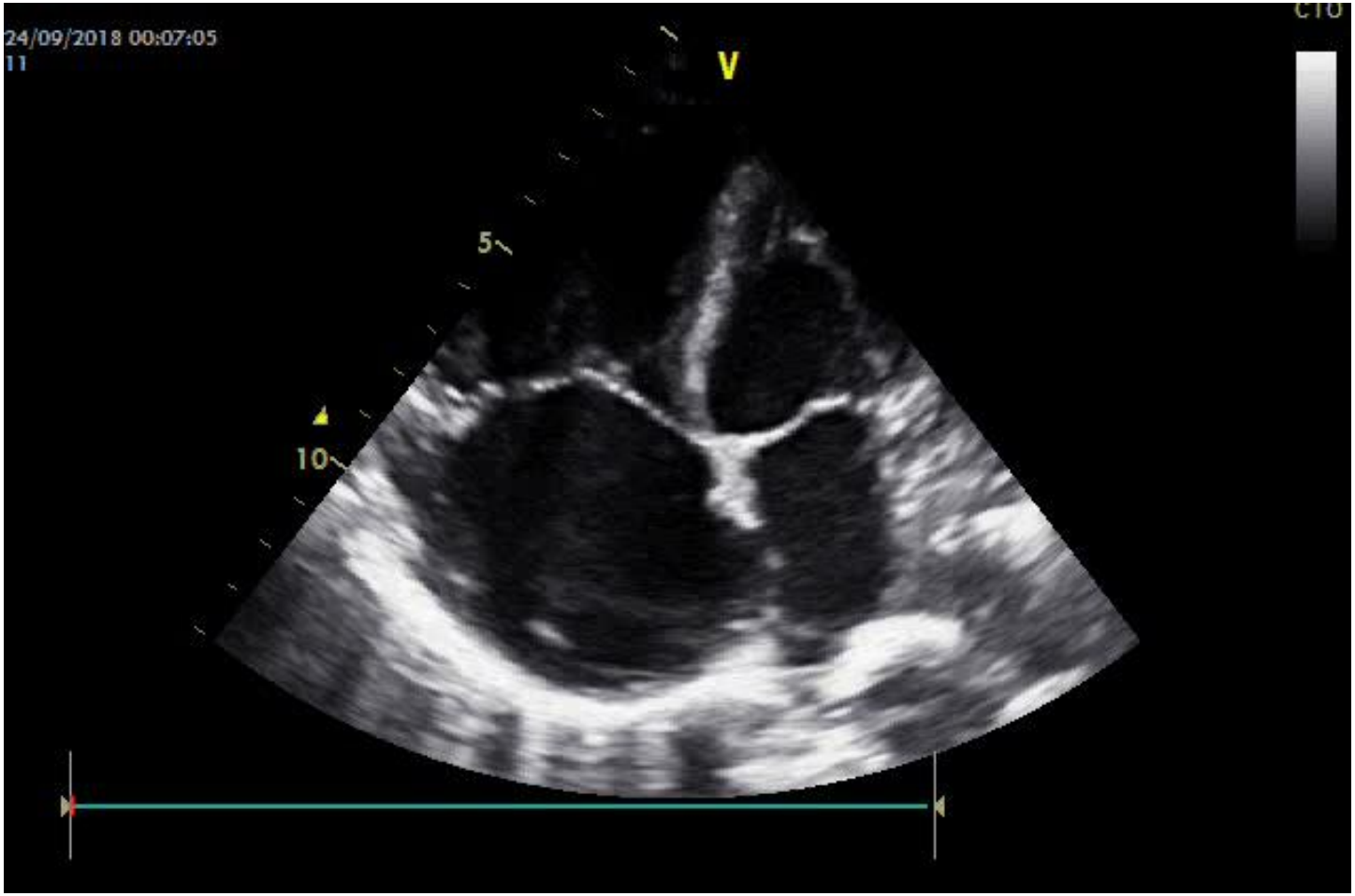
Spontaneous breathing trial



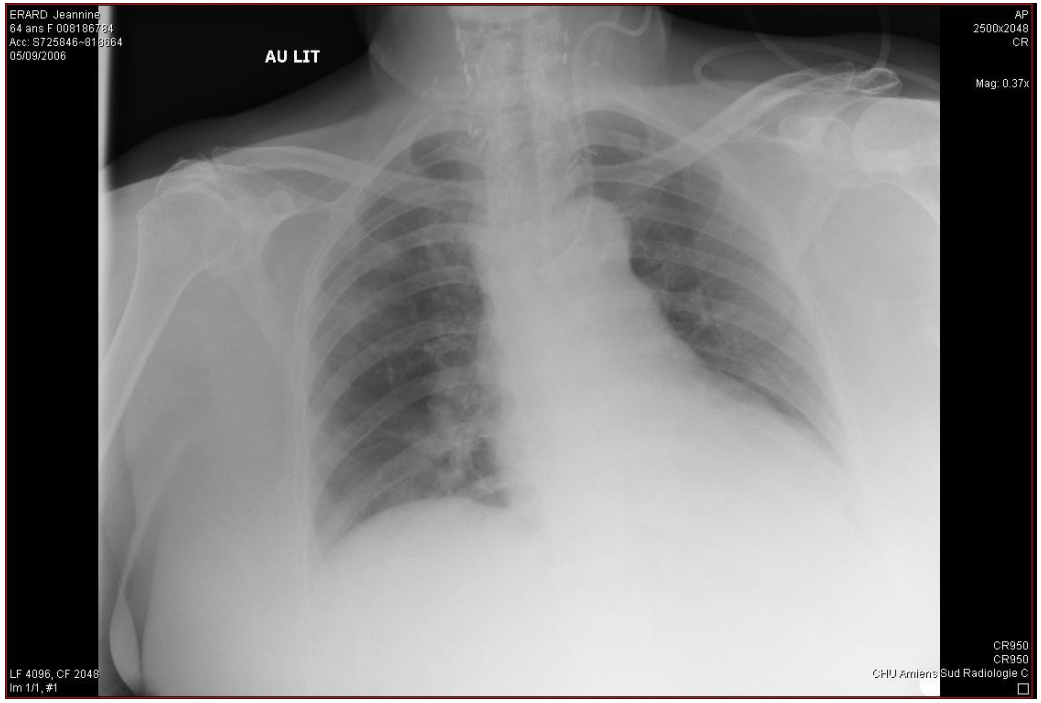


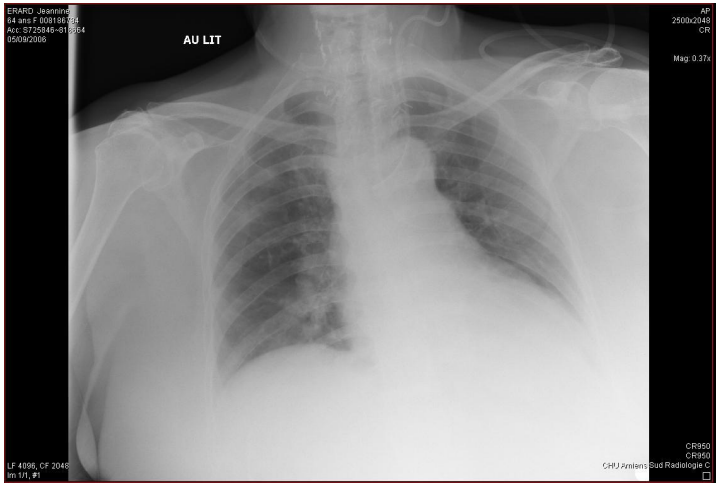


Step 5: RV assessment in case of bilateral pneumonia or ARDS



Step 6: with A-lines and black chest X-Ray





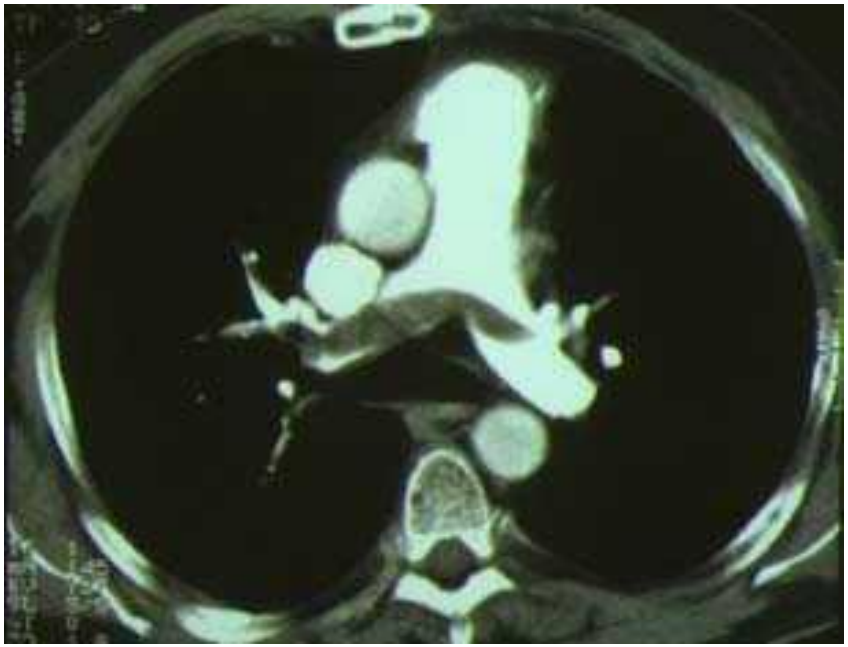
COPD

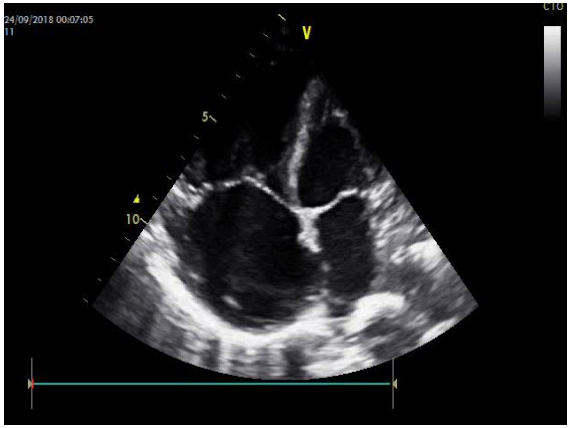
Pulmonary embolism

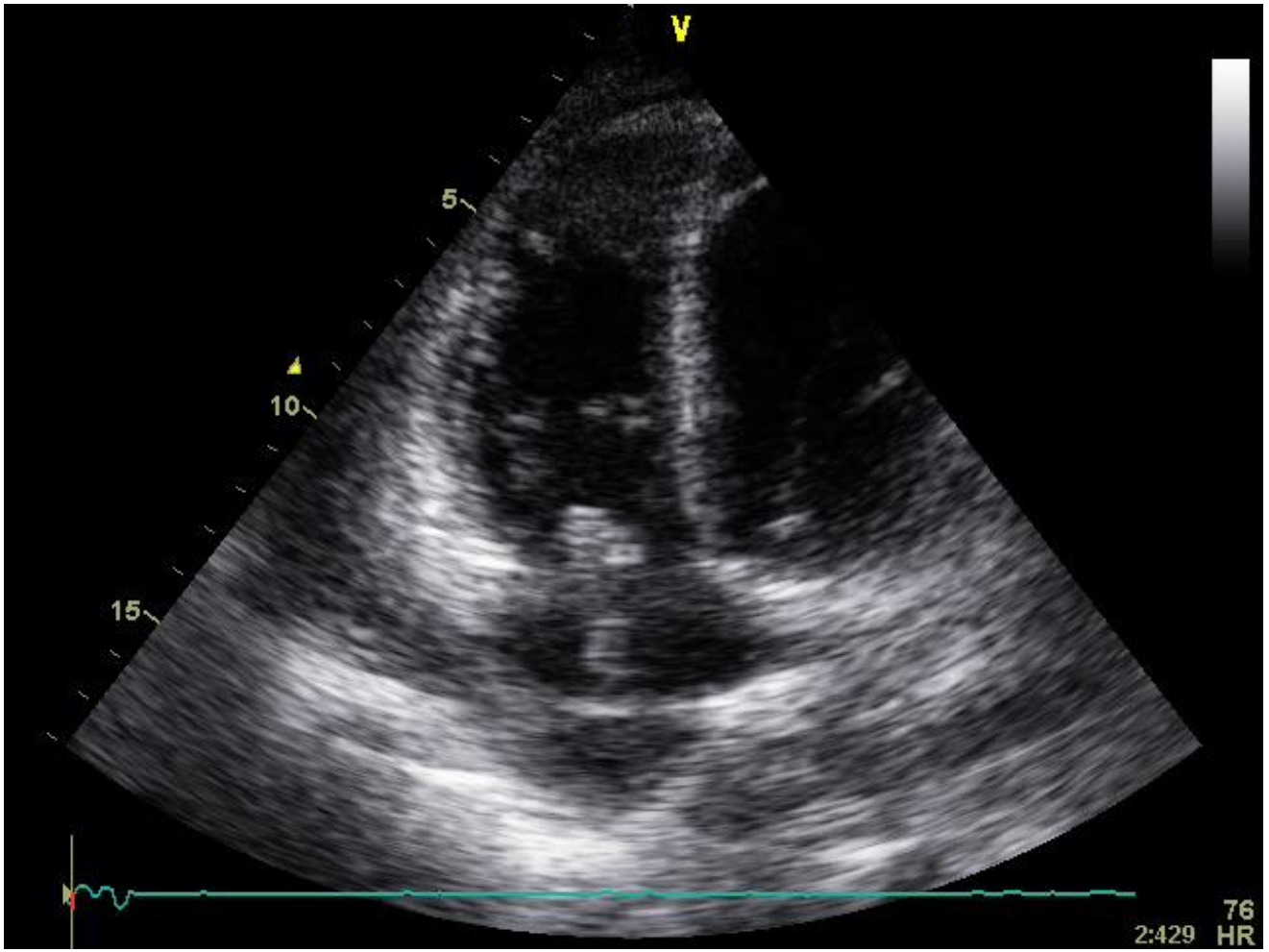
Intra cardiac or pulmonary shunt

Pulmonary embolism

- Echocardiography : ACP with RV dilation, paradoxical septum mouvement and PAH.
- Venous Doppler
- CT Scan

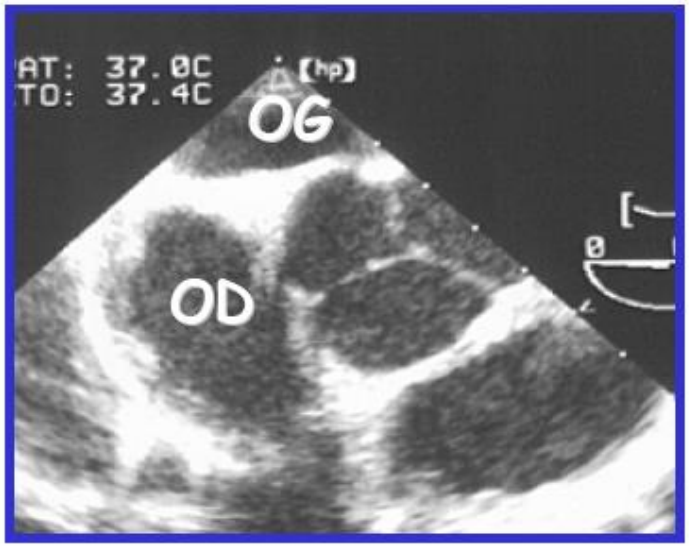





V
5
10
15
76
2:429 HR

Contrast echocardiography

Principle : injection of liquid with microbubbles in suspension into peripheral vein and assess right to left cardiac shunt



Semi quantitative assessment of shunt

Grade 1

Small

Grade 2

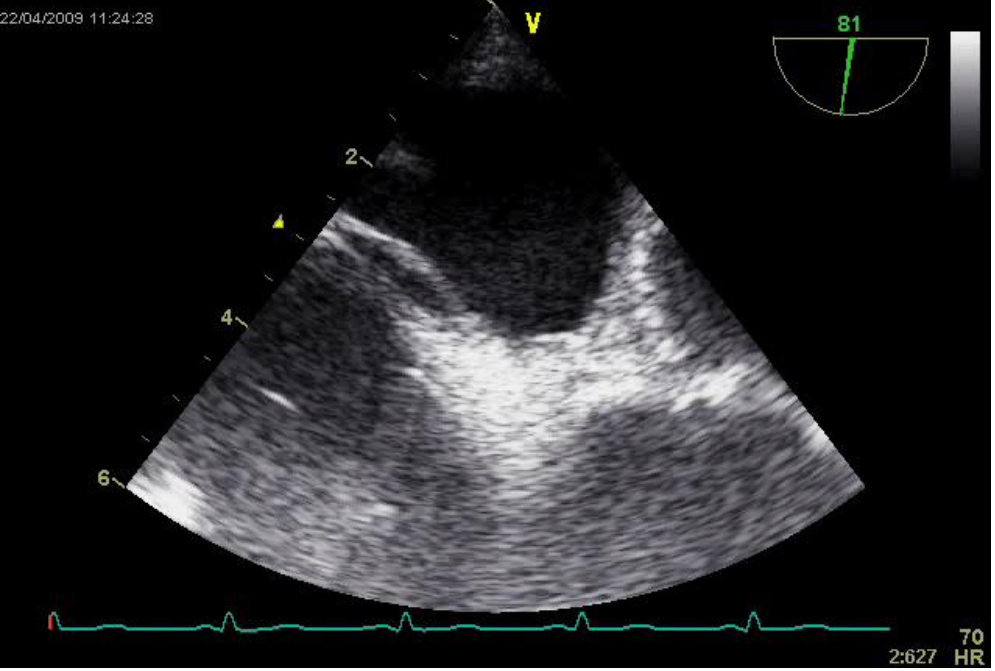
Moderate

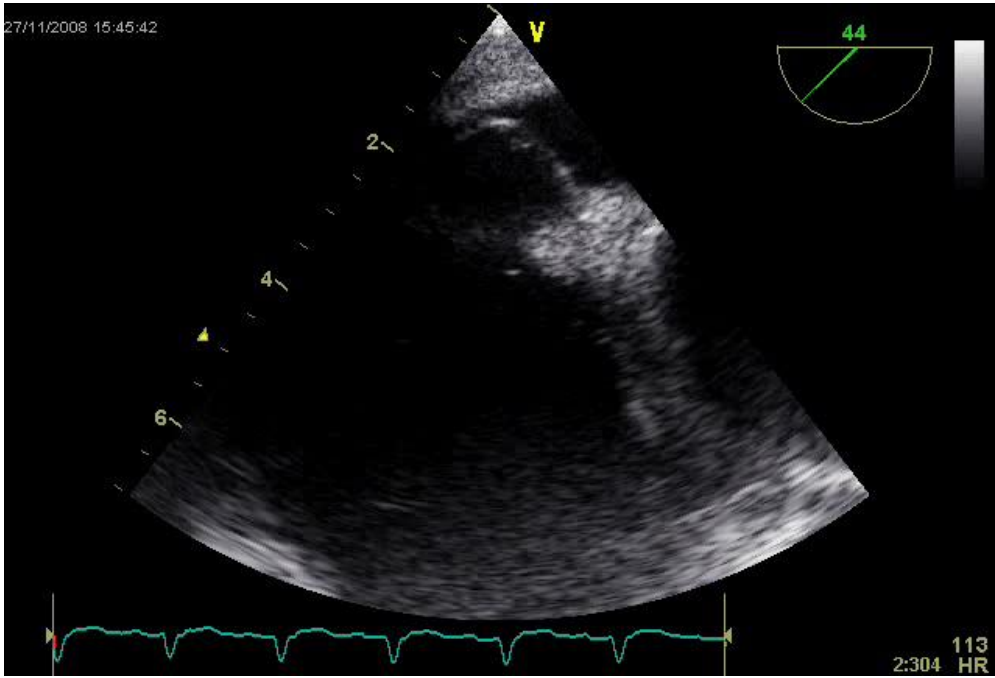
Grade 3

Important

Grade 4

Severe


22/04/2009 11:24:28
V
81
2
4
6
70
2:627 HR


27/11/2008 15:45:42
V
44
2
4
6
113
2:304 HR

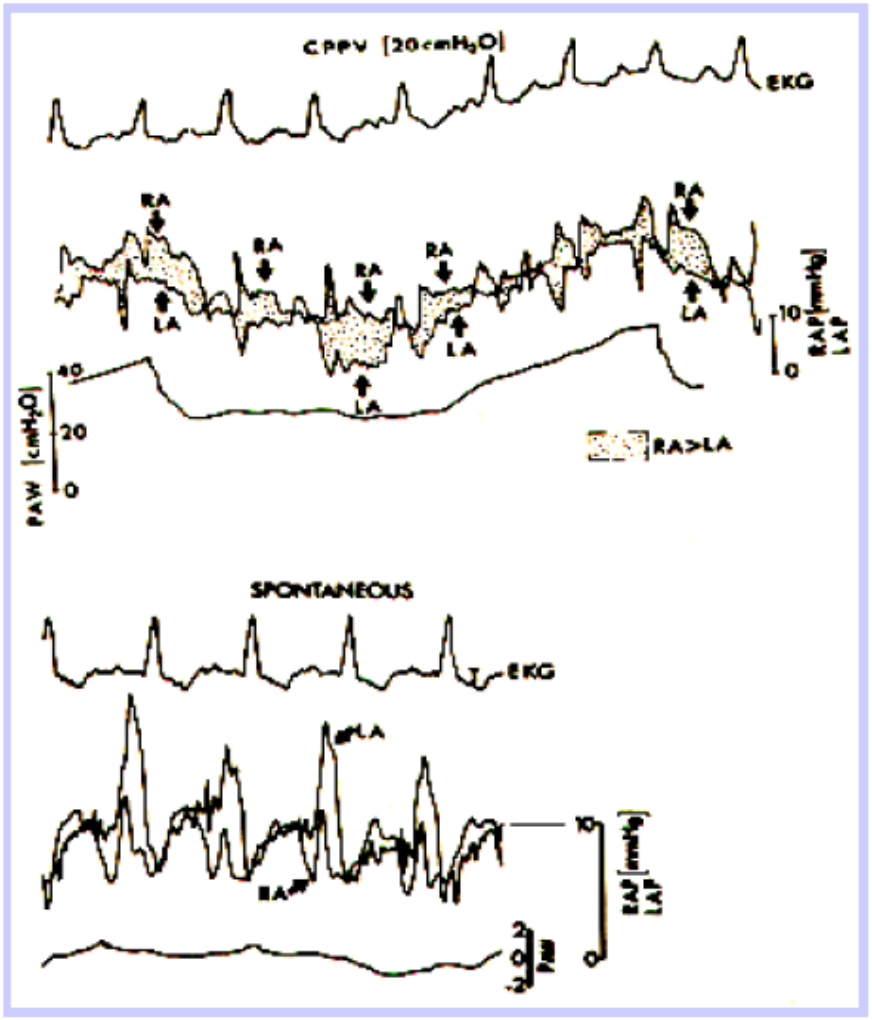
Distinction between PFO and intra pulmonary shunt

- PFO : bubbles in LA during the 3 first cardiac beats after contrast injection
- IPS : usually after 3 cardiac beats

Lemaire, Anesthesiology 1982

	PaO2
PEP 10	67 mmHg
PEP 0	293 mmHg
VS	335 mmHg
VS + FOP fermé	486 mmHg

Closed PFO



Conclusion

- Use critical care echocardiography and lung ultrasound to solve the clinical problem
- Rule out hemothorax and pneumothorax using lung ultrasound
- Use echocardiography and Doppler to assess the cause of pulmonary edema.
- In patient under mechanical ventilation with refractory hypoxemia without obvious cause do contrast examination.
- **The critical point in ICU is to do a follow-up**