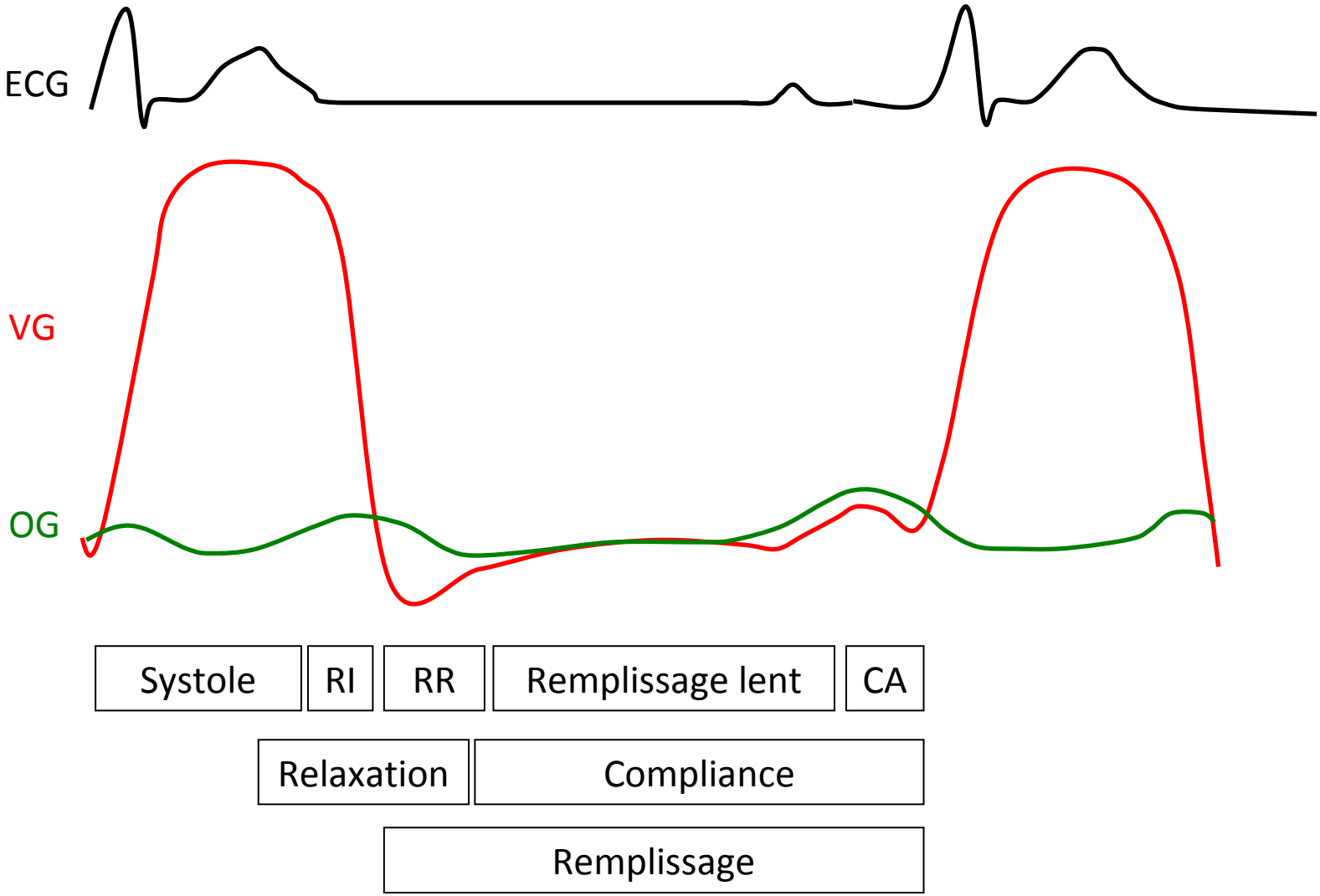
Fonction diastolique ventriculaire

Julien Maizel

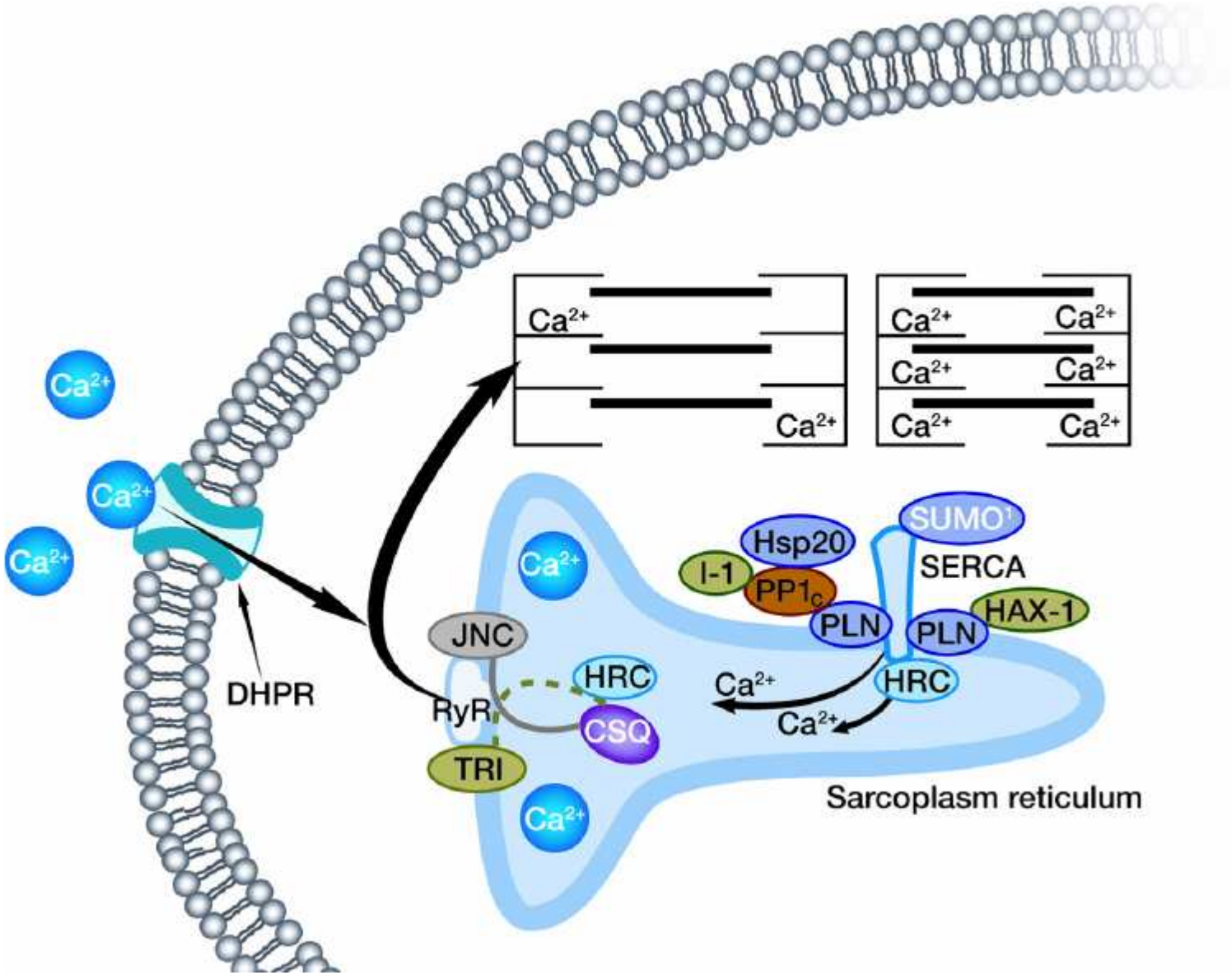
DESC Réanimation, Amiens 12 Décembre 2013

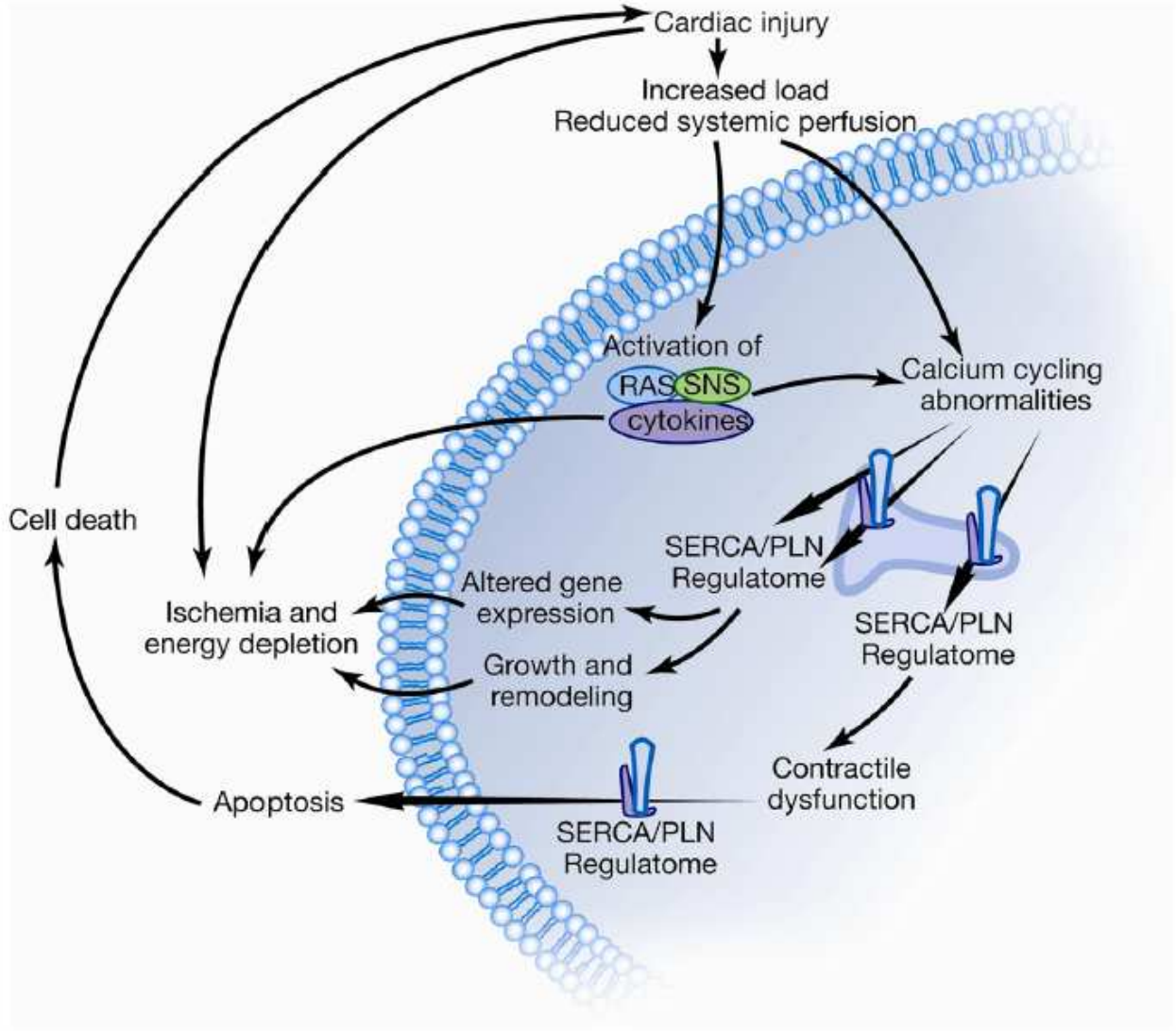
- Mécanismes physiologiques de la fonction diastolique
- La dysfonction diastolique
- Techniques d’analyse de la fonction diastolique
- Applications cliniques en réanimation, traitements

Fonction diastolique = dynamique de relaxation et de remplissage du ventricule gauche


ECG
VG
OG
Systole
RI
RR
Remplissage lent
CA
Relaxation
Compliance
Remplissage

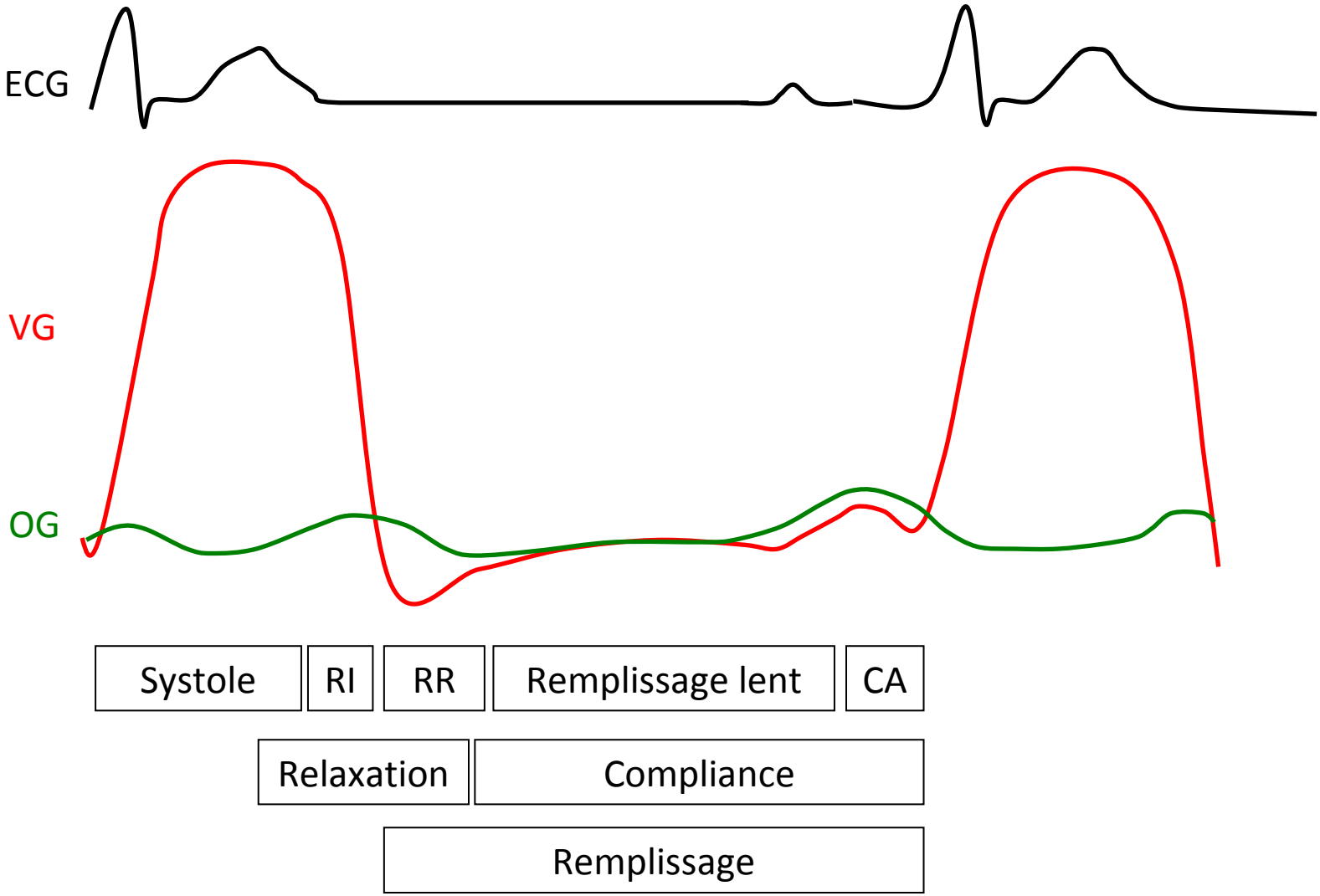
La relaxation



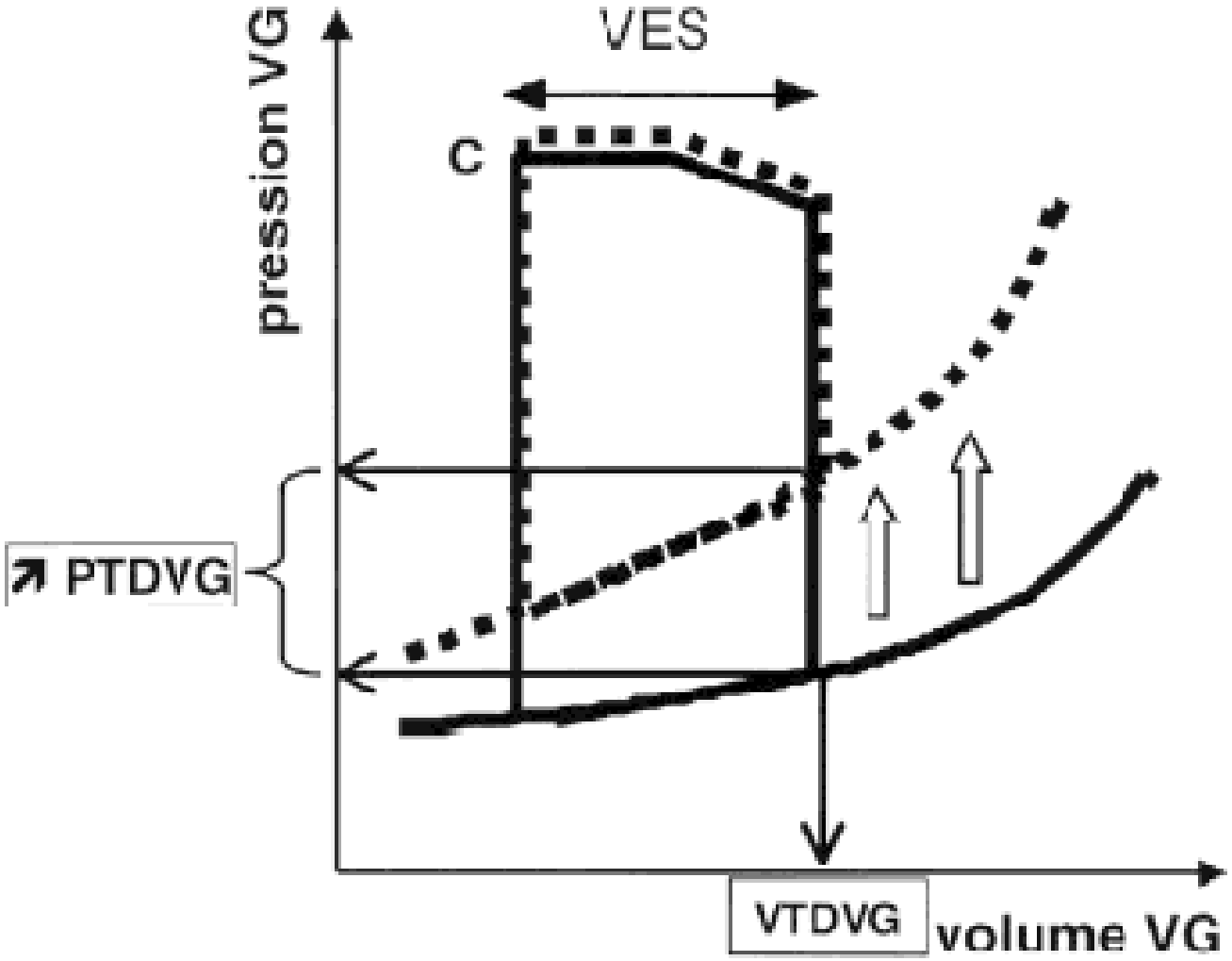

Cardiac injury
Increased load
Reduced systemic perfusion
Activation of
RAS
SNS
cytokines
Calcium cycling
abnormalities
Cell death
SERCA/PLN
Regulatome
Altered gene
expression
Ischemia and
energy depletion
Growth and
remodeling
SERCA/PLN
Regulatome
Contractile
dysfunction
Apoptosis
SERCA/PLN
Regulatome

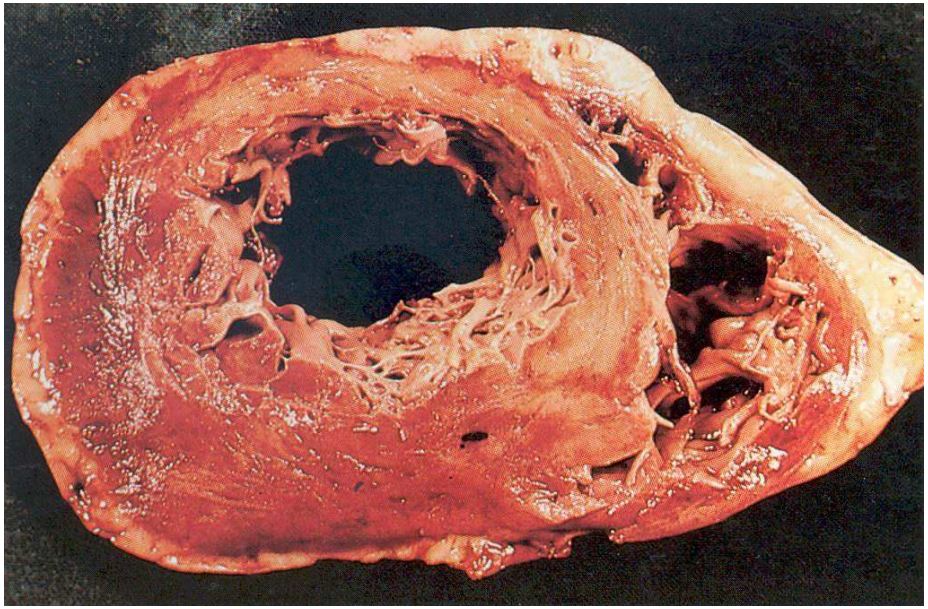
Relaxation

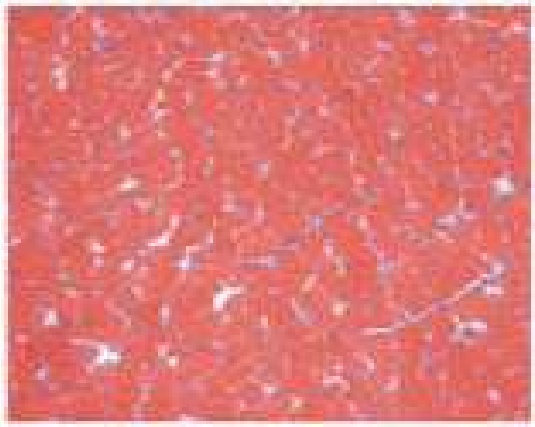
- Phénomène actif (consomme de l'ATP)
- Recapture du Ca dans le reticulum sarcoplasmique
- Plusieurs acteurs: Serca/Phospholamban, NCX

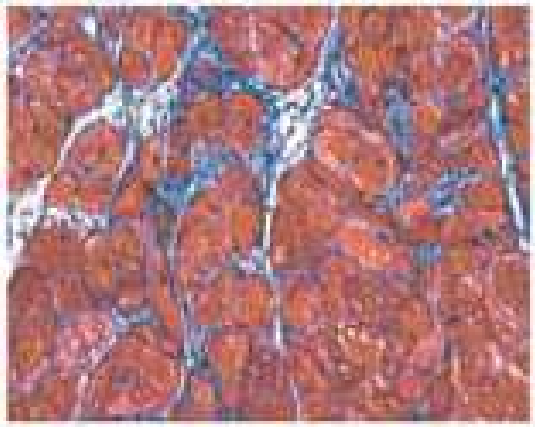

ECG
VG
OG
Systole
RI
RR
Remplissage lent
CA
Relaxation
Compliance
Remplissage

La compliance du VG: dV/dP

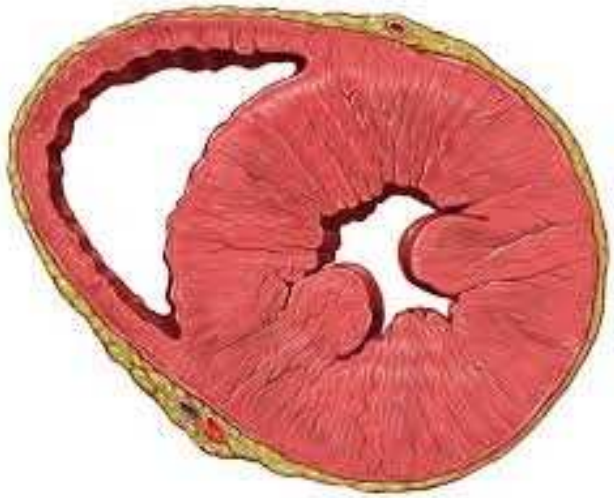




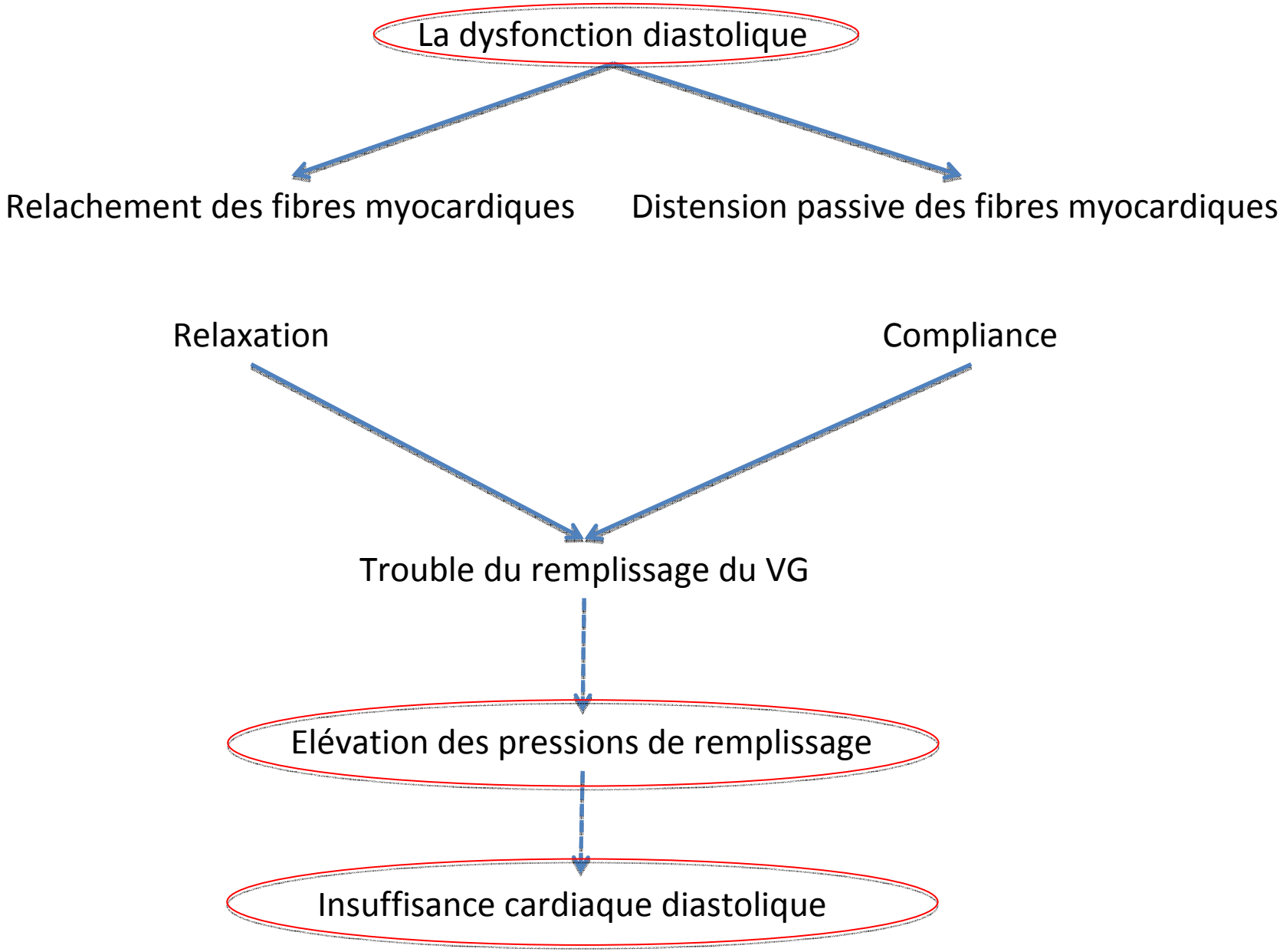




Hypertrophie ventriculaire gauche hypertensive ou CMH



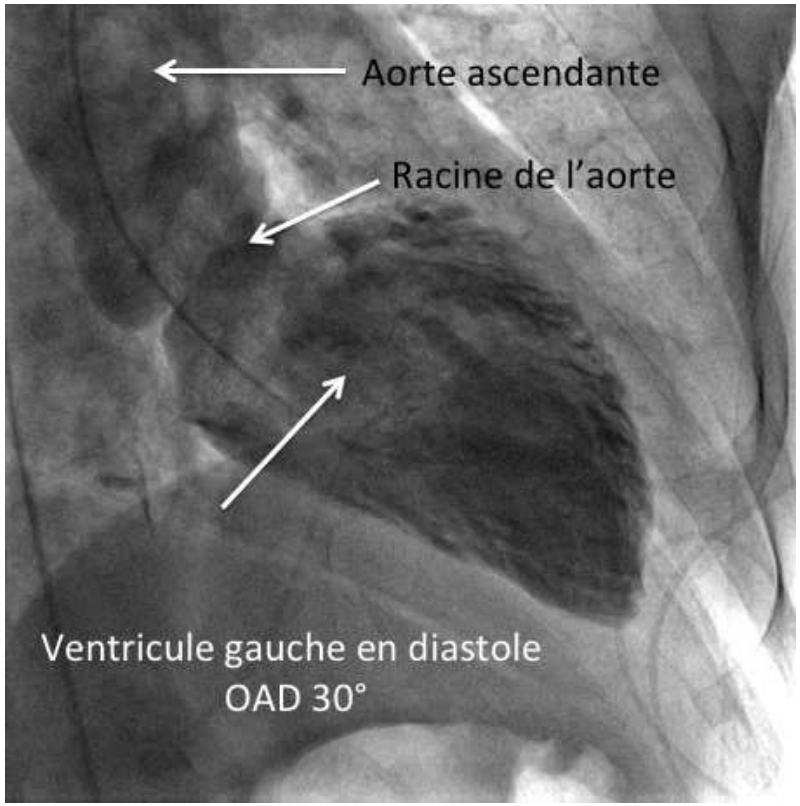
Altération de la relaxation + Altération de la compliance

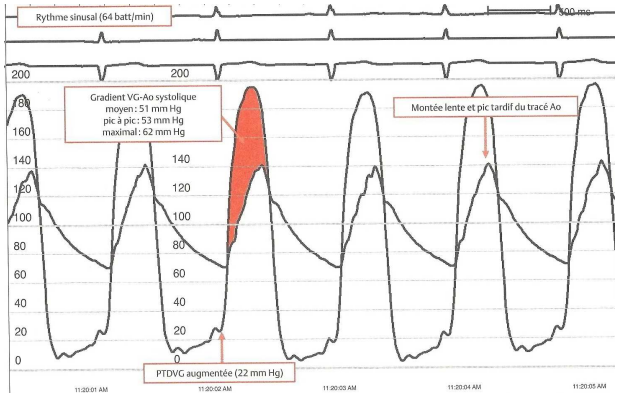

La dysfonction diastolique
Relachement des fibres myocardiques
Distension passive des fibres myocardiques
Relaxation
Compliance
Trouble du remplissage du VG
Elévation des pressions de remplissage
Insuffisance cardiaque diastolique

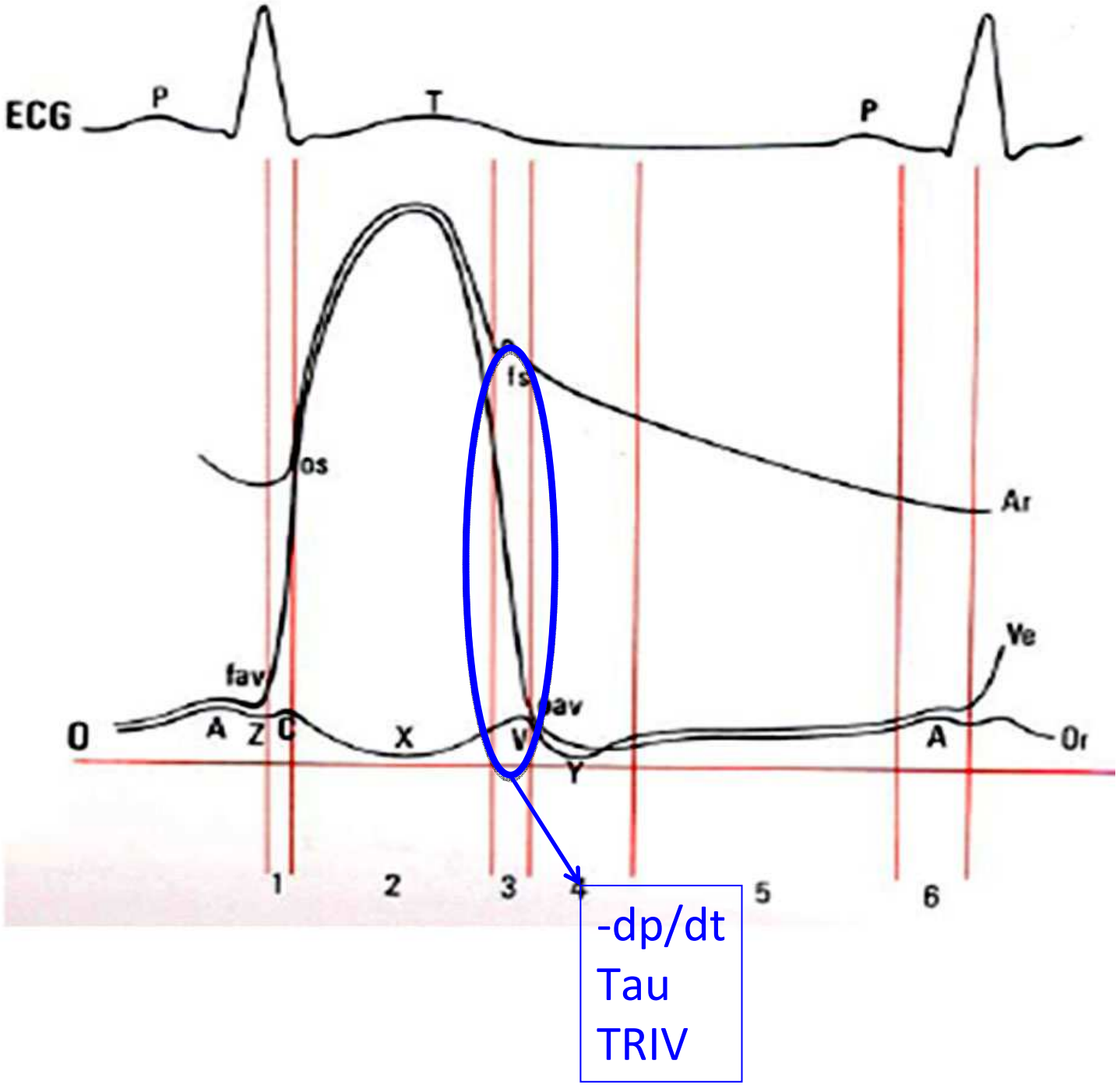
Exploration de la fonction diastolique

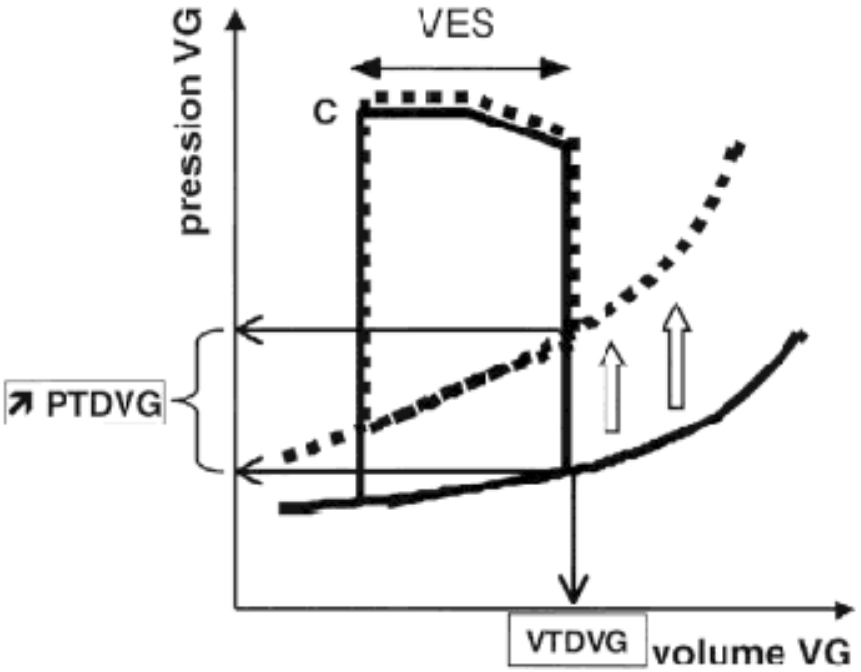
- Techniques invasives
- Echocardiographie

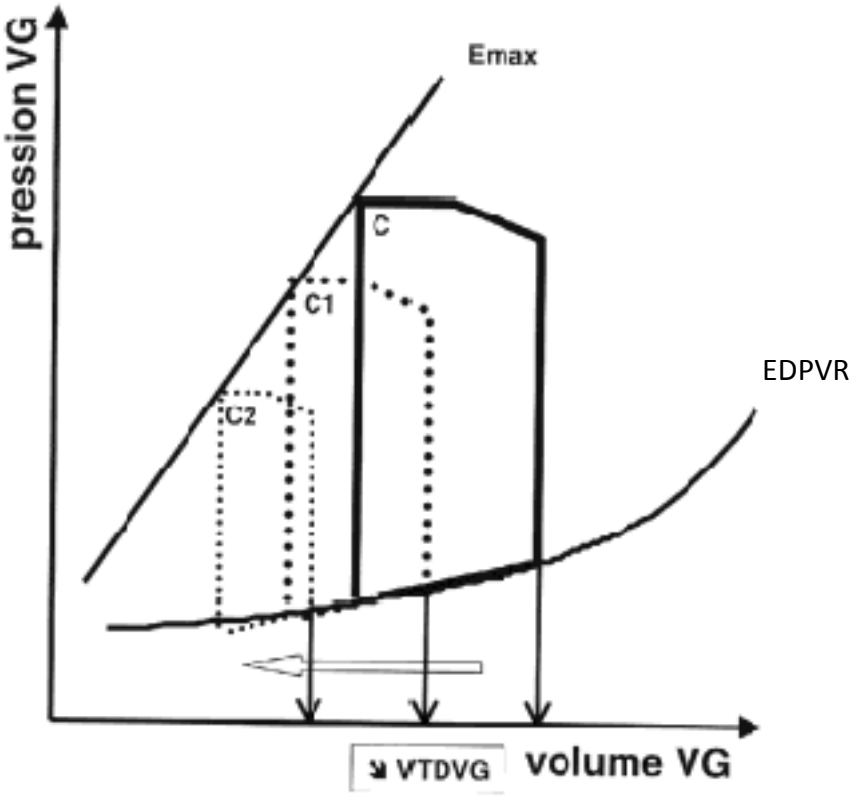
Exploration invasive de la fonction diastolique:

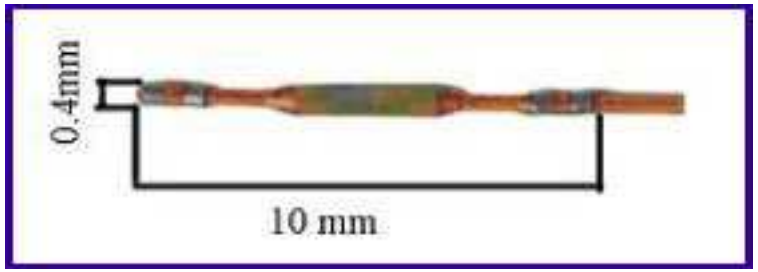


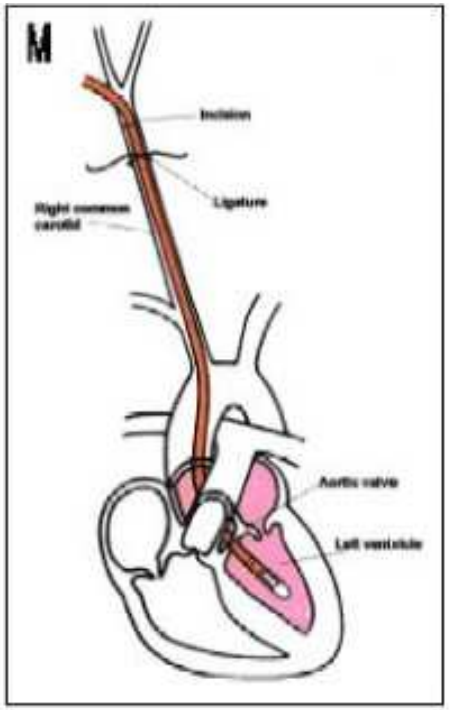


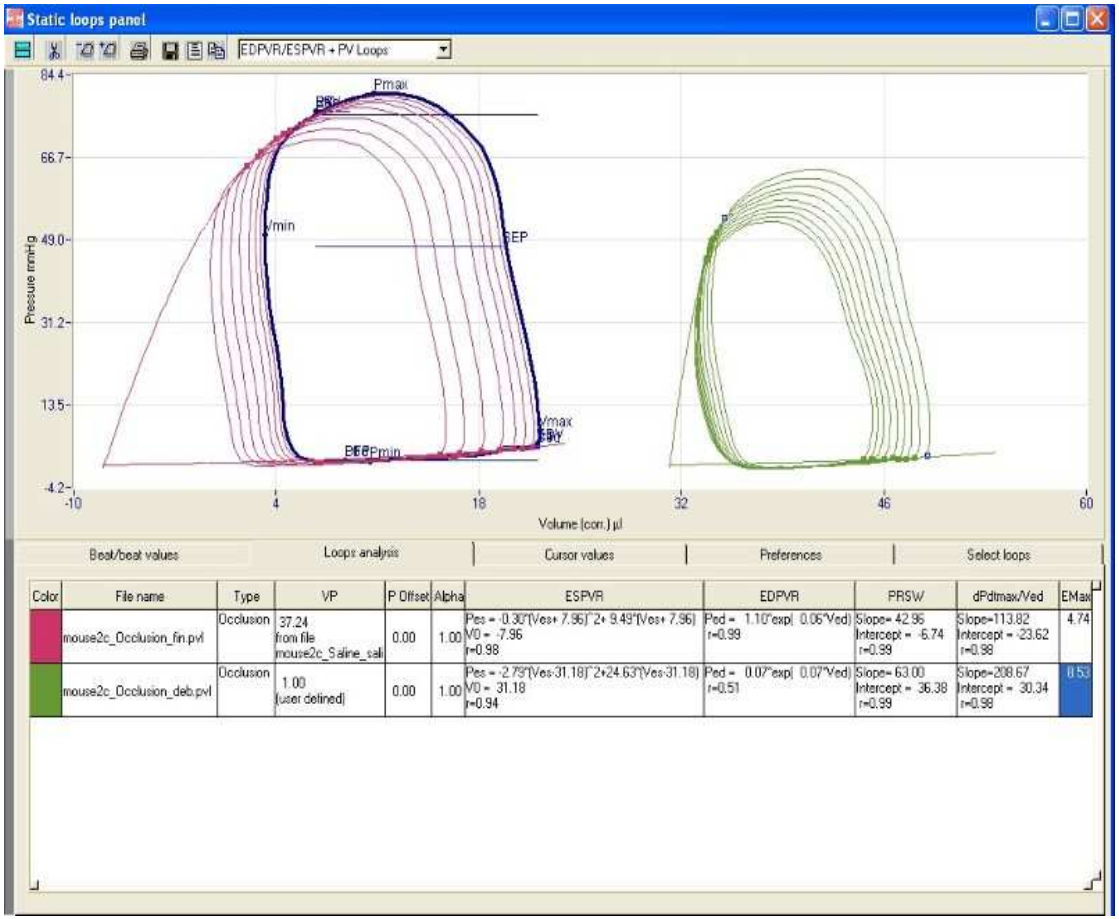

ECG
P
T
P
fs
os
Ar
Ve
fav
pav
O
A
Z
C
X
V
Y
A
Or
1
2
3
4
5
6
-dp/dt
Tau
TRIV

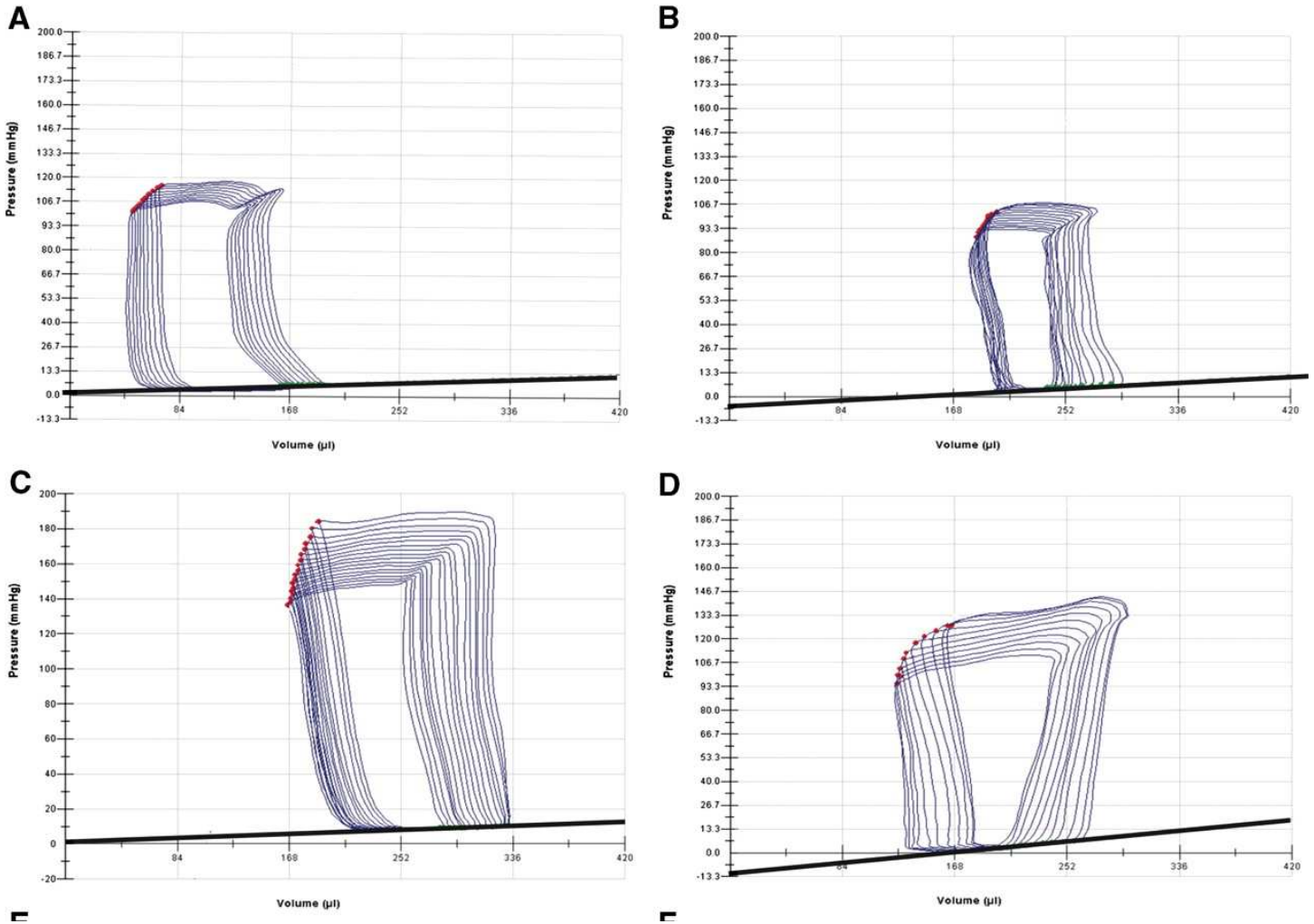

pression VG
VES
C
↗ PTDVG
VTDVG
volume VG


pression VG
Emax
C
C1
C2
EDPVR
↘ VTDVG
volume VG


0,4mm
10 mm

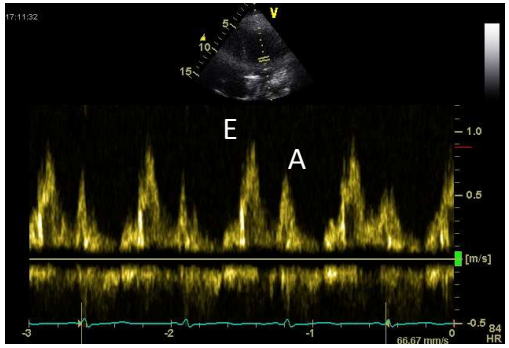

M
Incision
Ligature
Right common carotid
Aortic valve
Left ventricle


Static loops panel
EDPVR/ESPVR + PV Loops
Pmax
dP/dtmax
dV/dtmin
ESP
Vmax
ESW
Pmin
Pressure mmHg
84.4
66.7
49.0
31.2
13.5
-4.2
-10
4
18
32
46
60
Volume (corr.) µl
Beat/beat values
Loops analysis
Cursor values
Preferences
Select loops
Color
File name
Type
VP
P Offset
Alpha
ESPVR
EDPVR
PRSW
dPdtmax/Ved
EMax
mouse2c_Occlusion_fin.pvl
Occlusion
37.24
from file
mouse2c_Saline_sali
0.00
1.00
Pes = -0.30*(Ves+ 7.96)^2+ 9.49*(Ves+ 7.96)
V0 = -7.96
r=0.98
Ped = 1.10*exp(0.06*Ved)
r=0.99
Slope= 42.96
Intercept = -6.74
r=0.99
Slope=113.82
Intercept = -23.62
r=0.98
4.74
mouse2c_Occlusion_deb.pvl
Occlusion
1.00
(user defined)
0.00
1.00
Pes = -2.79*(Ves-31.18)^2+24.63*(Ves-31.18)
V0 = 31.18
r=0.94
Ped = 0.07*exp(0.07*Ved)
r=0.51
Slope= 63.00
Intercept = 36.38
r=0.99
Slope=208.67
Intercept = 30.34
r=0.98
8.53

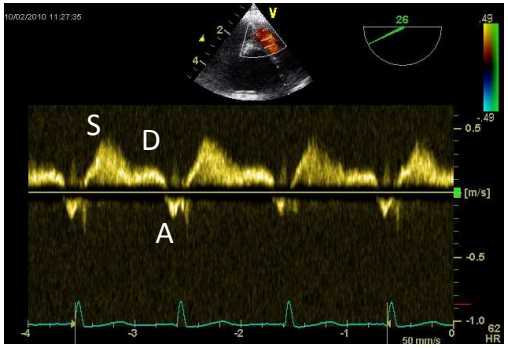

A
B
C
D
Pressure (mmHg)
Volume (µl)
200.0
186.7
173.3
160.0
146.7
133.3
120.0
106.7
93.3
80.0
66.7
53.3
40.0
26.7
13.3
0.0
-13.3
200
180
160
140
120
100
80
60
40
20
0
-20
84
168
252
336
420

Echocardiographie

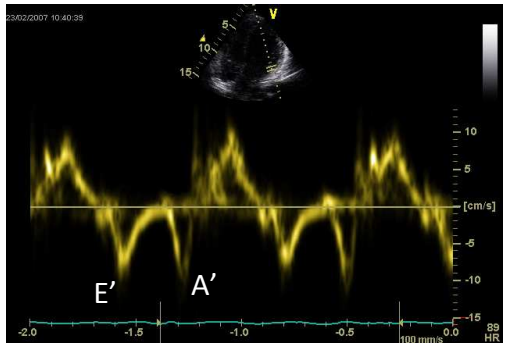
A



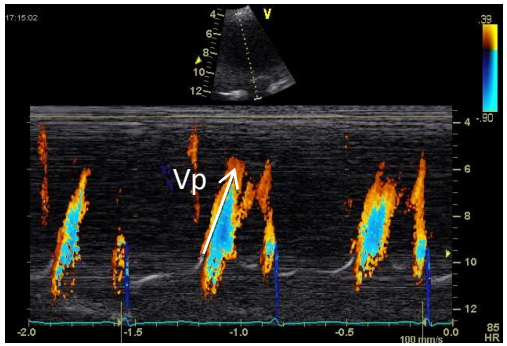
B



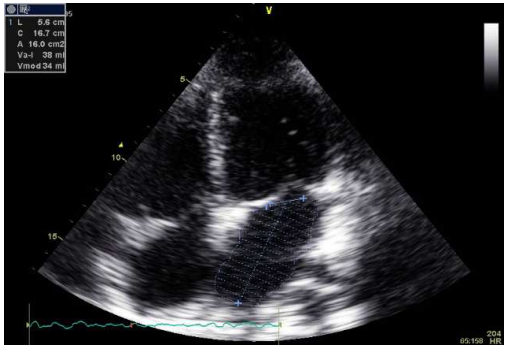
C



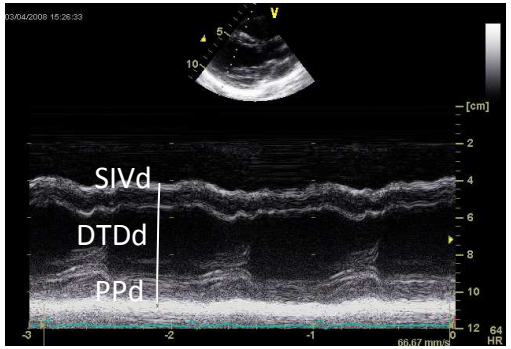
D

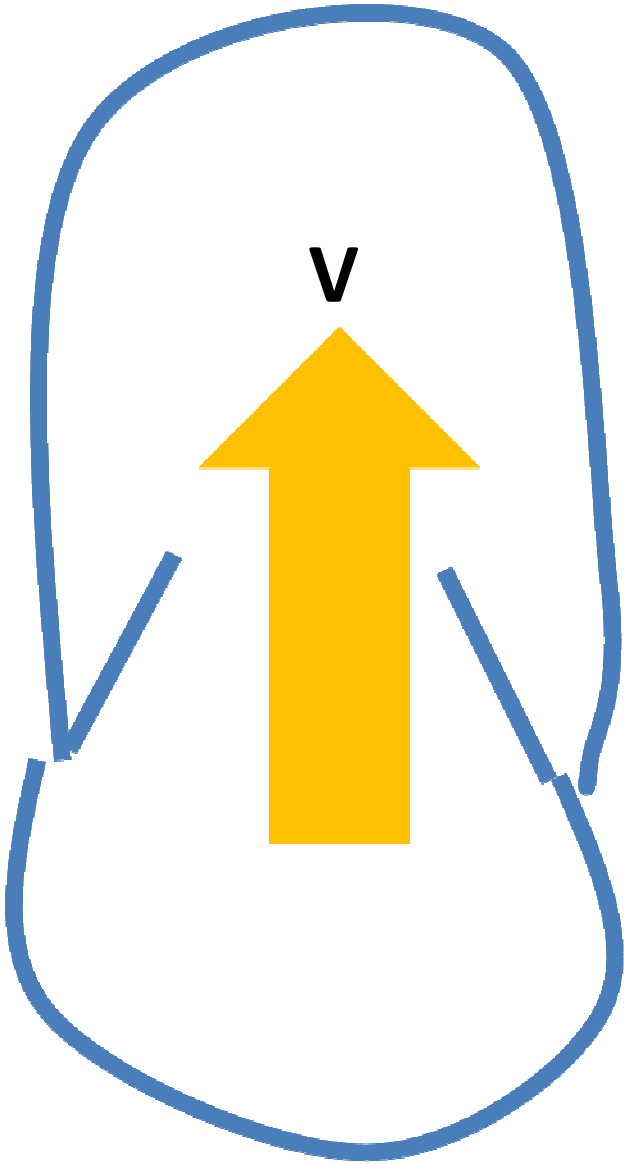


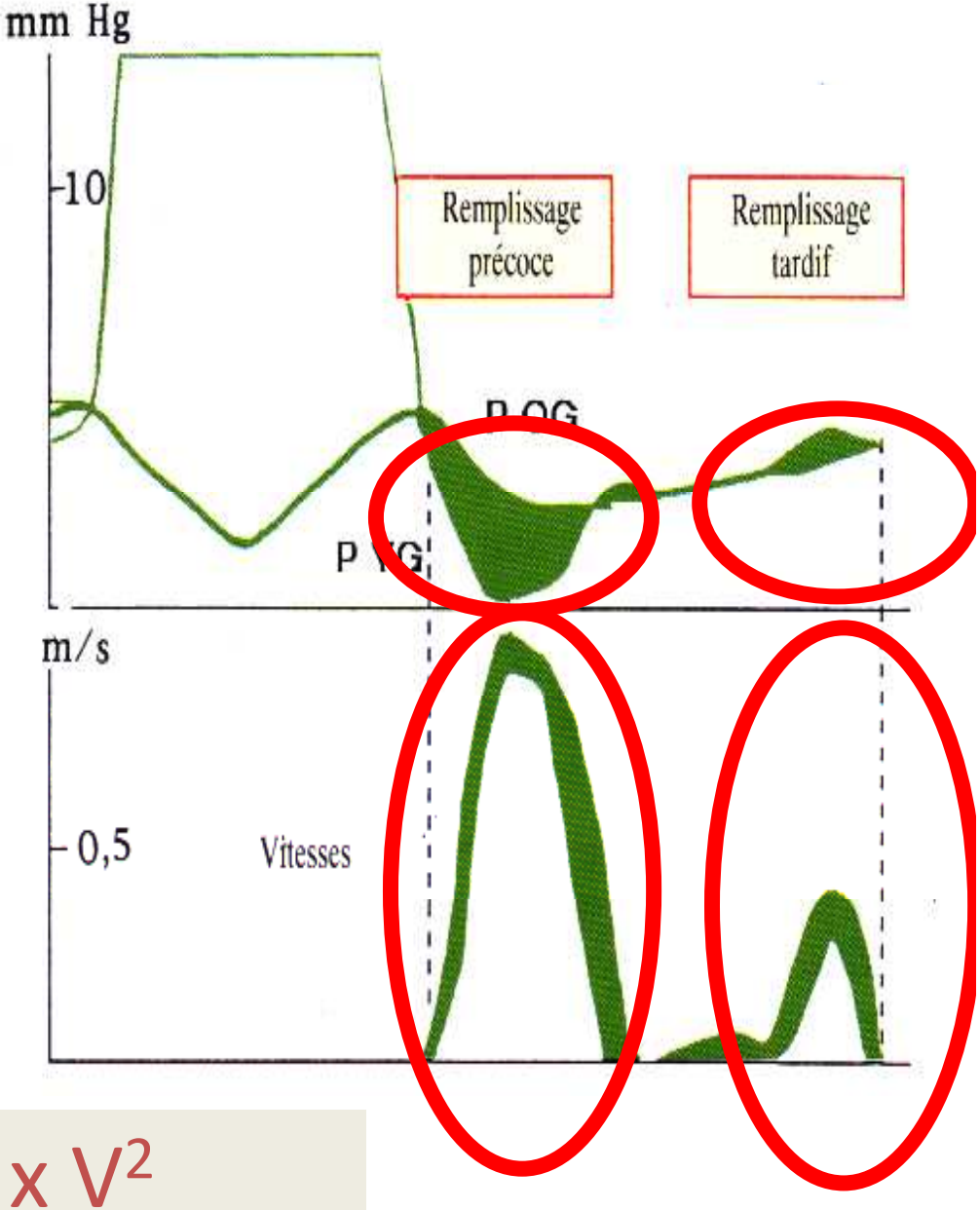
E



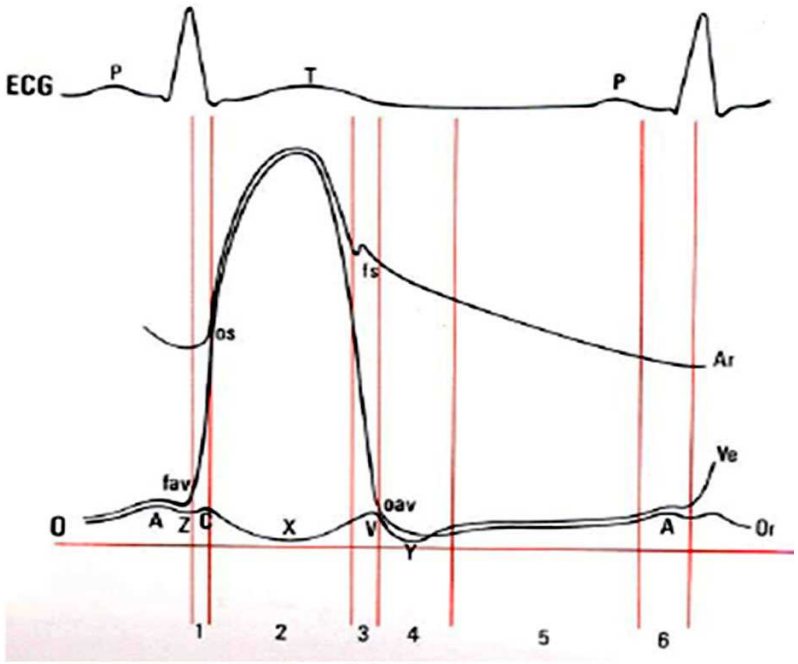
F

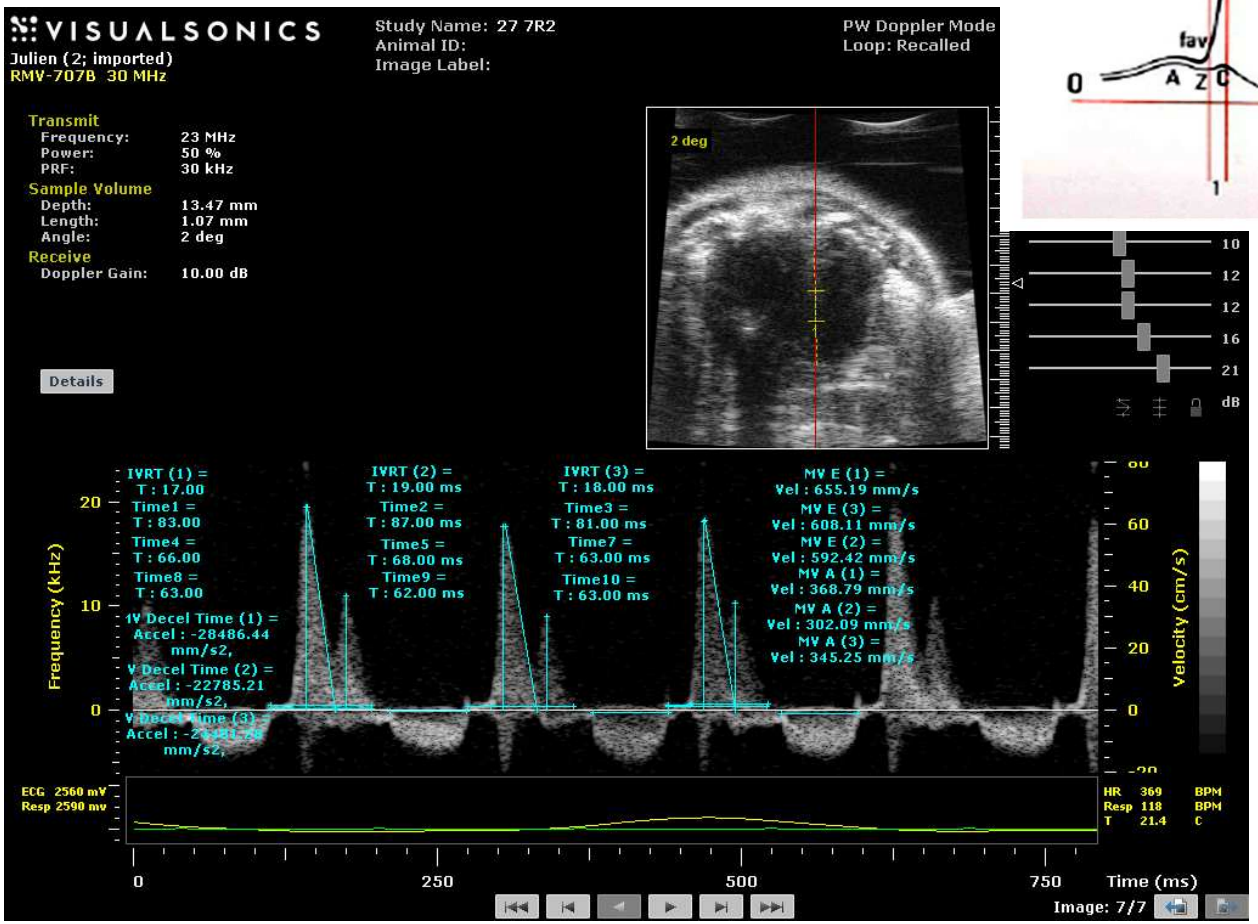


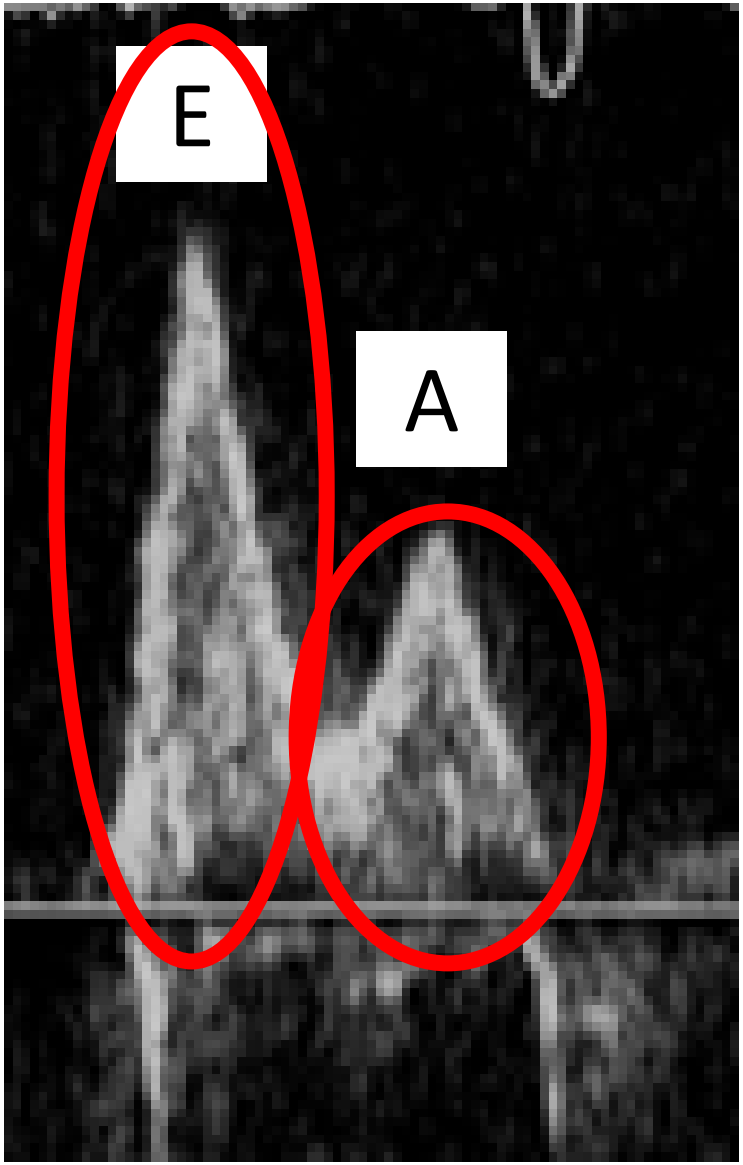


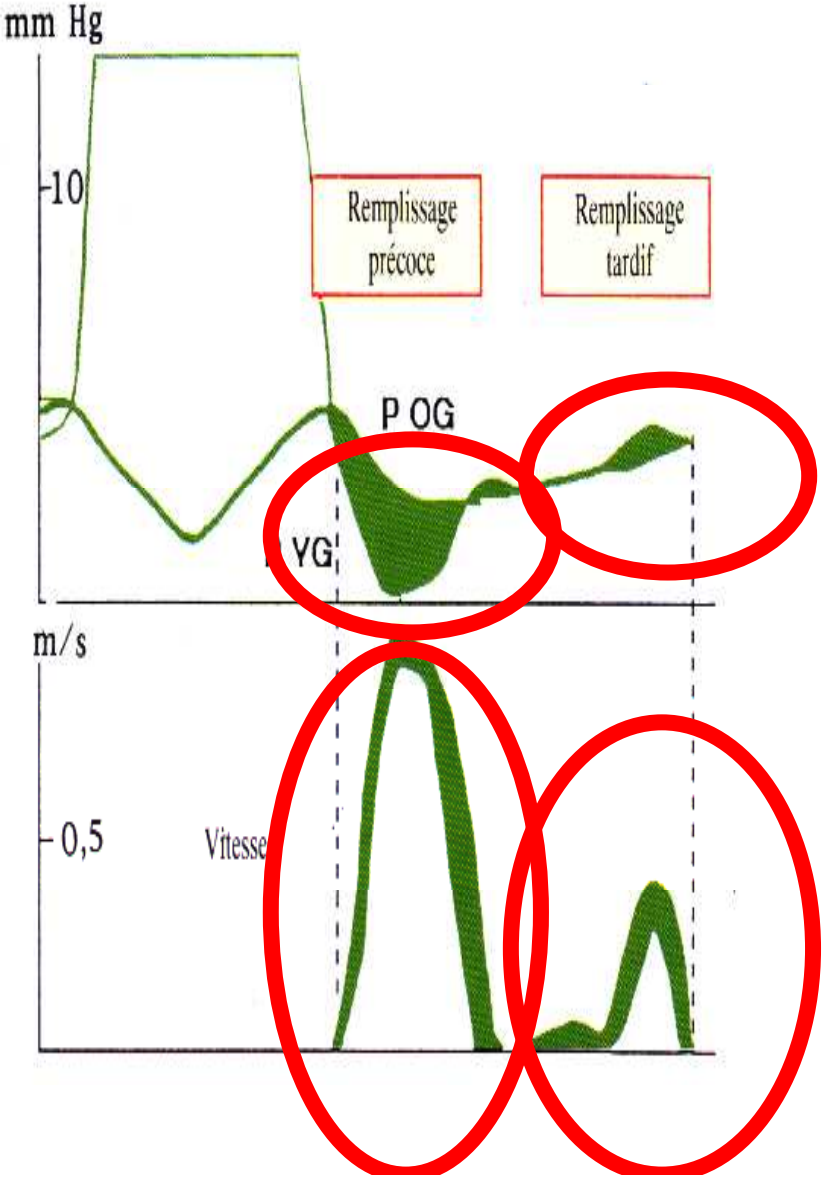


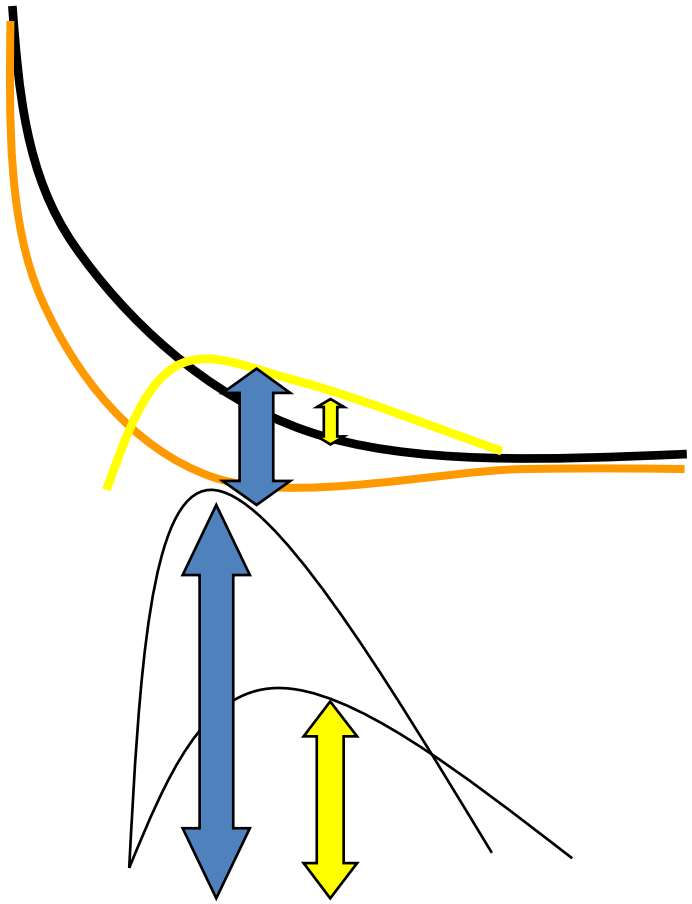
$LVP-LAP= 4 \times V^2$

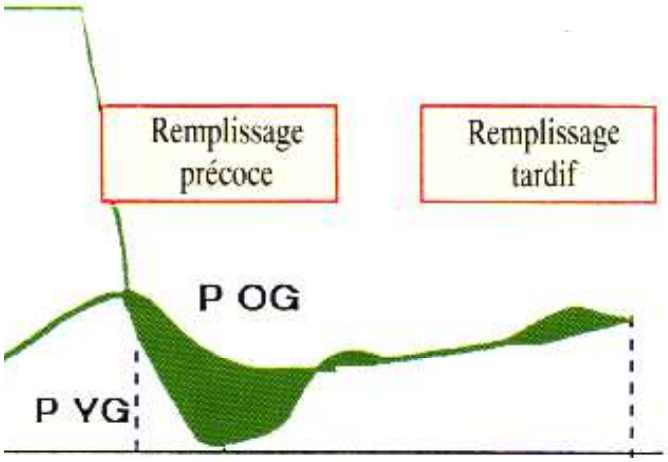

ECG
P
T
P
os
fs
Ar
Ve
fav
oav
0
A
Z
C
X
V
Y
A
Ar
1
2
3
4
5
6

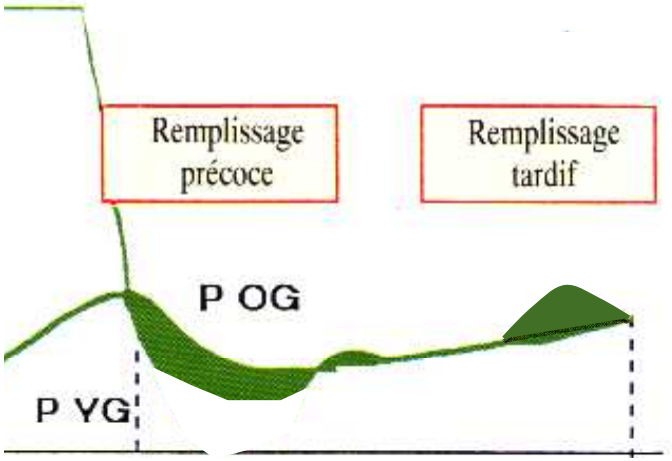

VISUALSONICS
Julien (2; imported)
RMV-707B 30 MHz
Study Name: 27 7R2
Animal ID:
Image Label:
PW Doppler Mode
Loop: Recalled
Transmit
Frequency: 23 MHz
Power: 50 %
PRF: 30 kHz
Sample Volume
Depth: 13.47 mm
Length: 1.07 mm
Angle: 2 deg
Receive
Doppler Gain: 10.00 dB
Details
2 deg
10
12
12
16
21
dB
IVRT (1) = T : 17.00
Time1 = T : 83.00
Time4 = T : 66.00
Time8 = T : 63.00
IVRT (2) = T : 19.00 ms
Time2 = T : 87.00 ms
Time5 = T : 68.00 ms
Time9 = T : 62.00 ms
IVRT (3) = T : 18.00 ms
Time3 = T : 81.00 ms
Time7 = T : 63.00 ms
Time10 = T : 63.00 ms
MV E (1) = Vel : 655.19 mm/s
MV E (3) = Vel : 608.11 mm/s
MV E (2) = Vel : 592.42 mm/s
MV A (1) = Vel : 368.79 mm/s
MV A (2) = Vel : 302.09 mm/s
MV A (3) = Vel : 345.25 mm/s
IV Decel Time (1) = Accel : -28486.44 mm/s2,
V Decel Time (2) = Accel : -22785.21 mm/s2,
V Decel Time (3) = Accel : -2[illegible] mm/s2,
Frequency (kHz)
Velocity (cm/s)
ECG 2560 mV
Resp 2590 mv
HR 369 BPM
Resp 118 BPM
T 21.4 C
0
250
500
750
Time (ms)
Image: 7/7

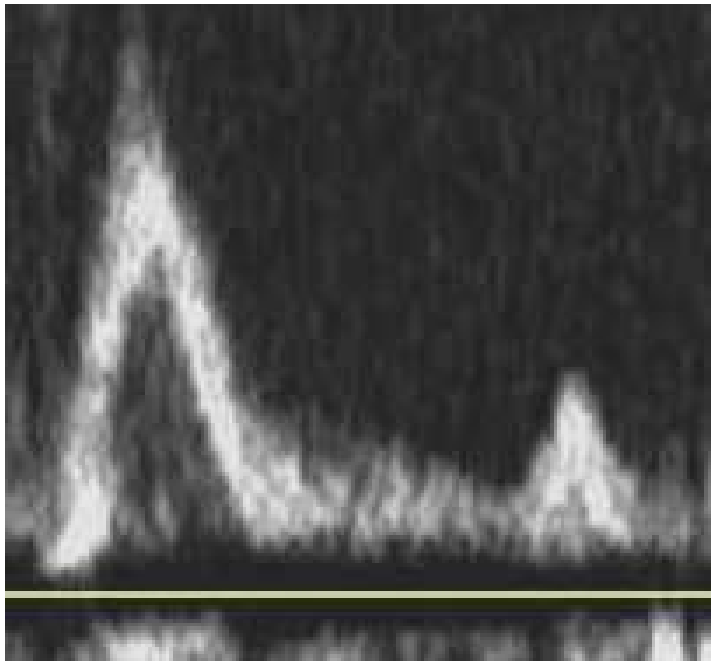

E
A

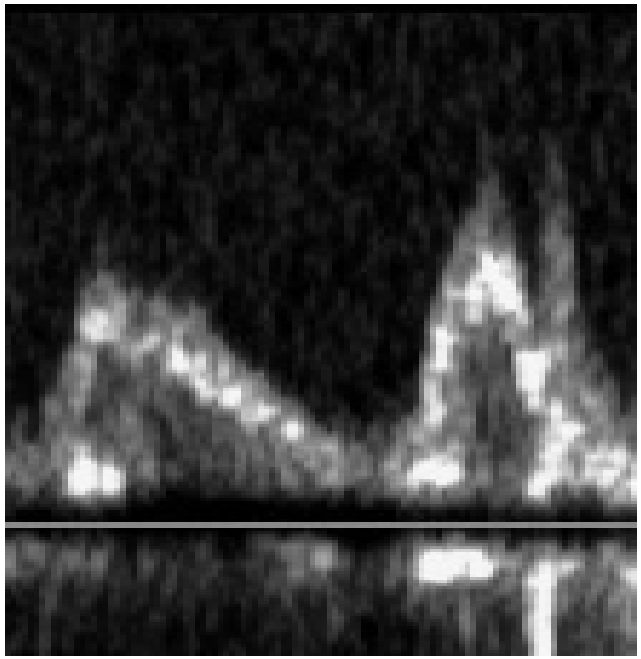

mm Hg
10
Remplissage précoce
Remplissage tardif
P OG
YG
m/s
0,5
Vitesse


LV Pressure
Mitral flow





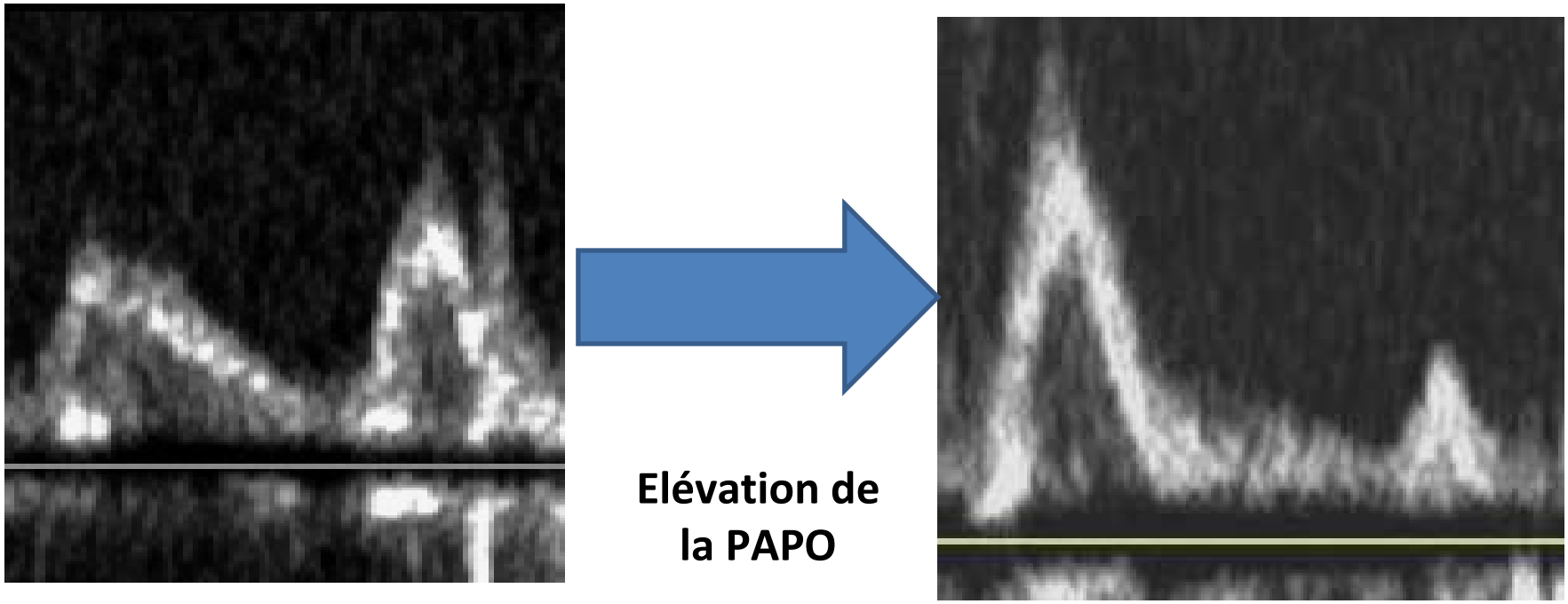




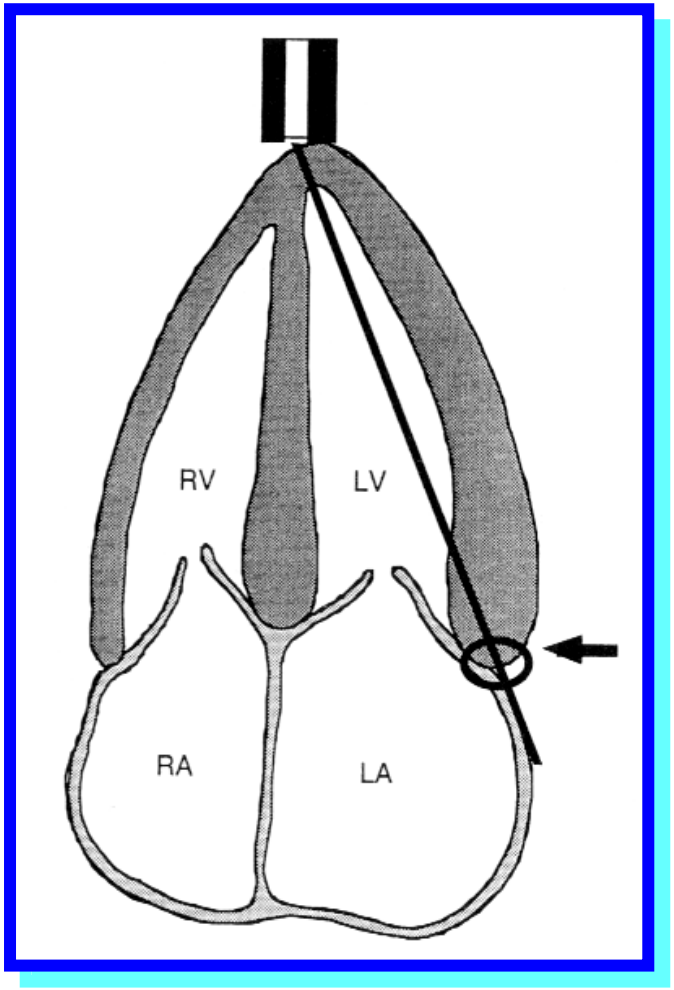
Normal

Trouble de la relaxation VG sans élévation des pressions de remplissage

Le flux mitral est dépendant de la PAPO

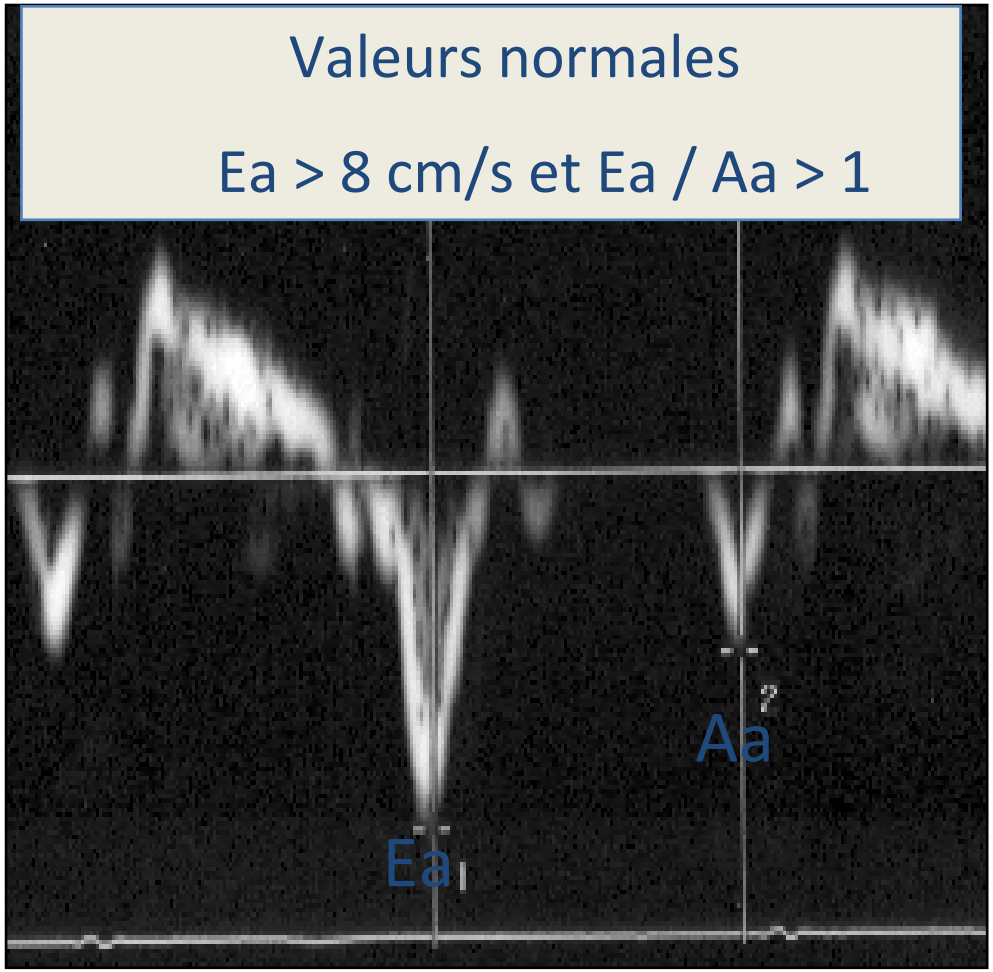


Comment évaluer la fonction diastolique indépendamment des conditions de charge?



Valeurs normales

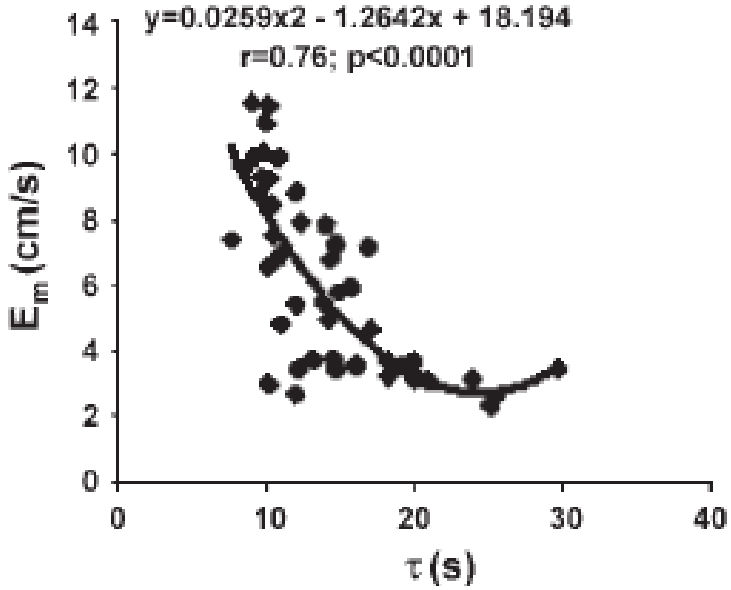
Ea > 8 cm/s et Ea / Aa > 1

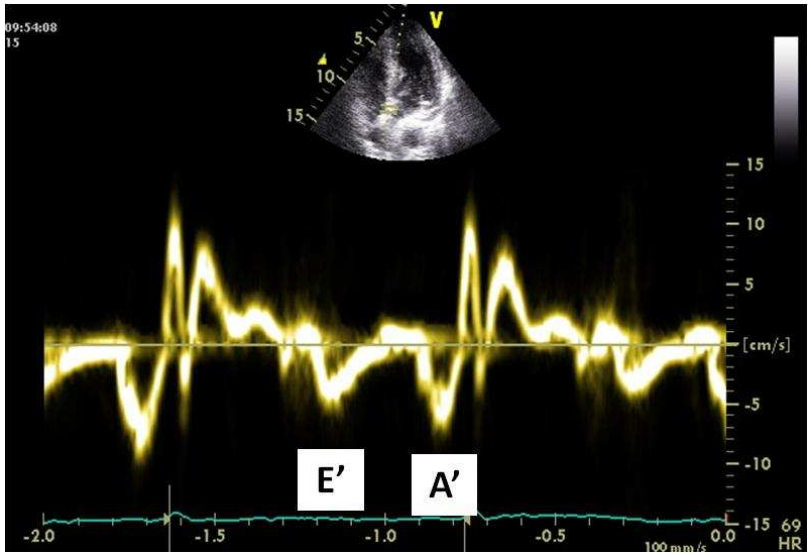


Ea = 15 ± 4 cm/s
Aa = 10 ± 3 cm/s

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

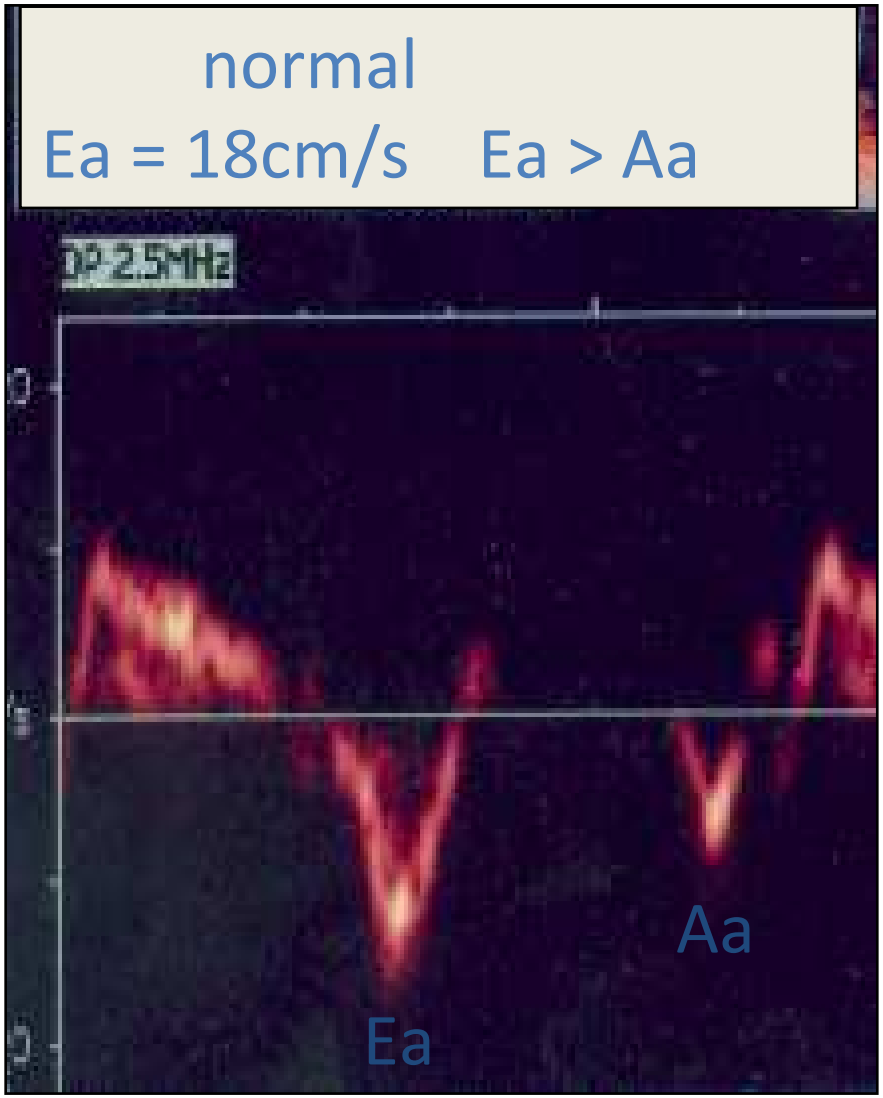




Déplacement de l'anneau mitral

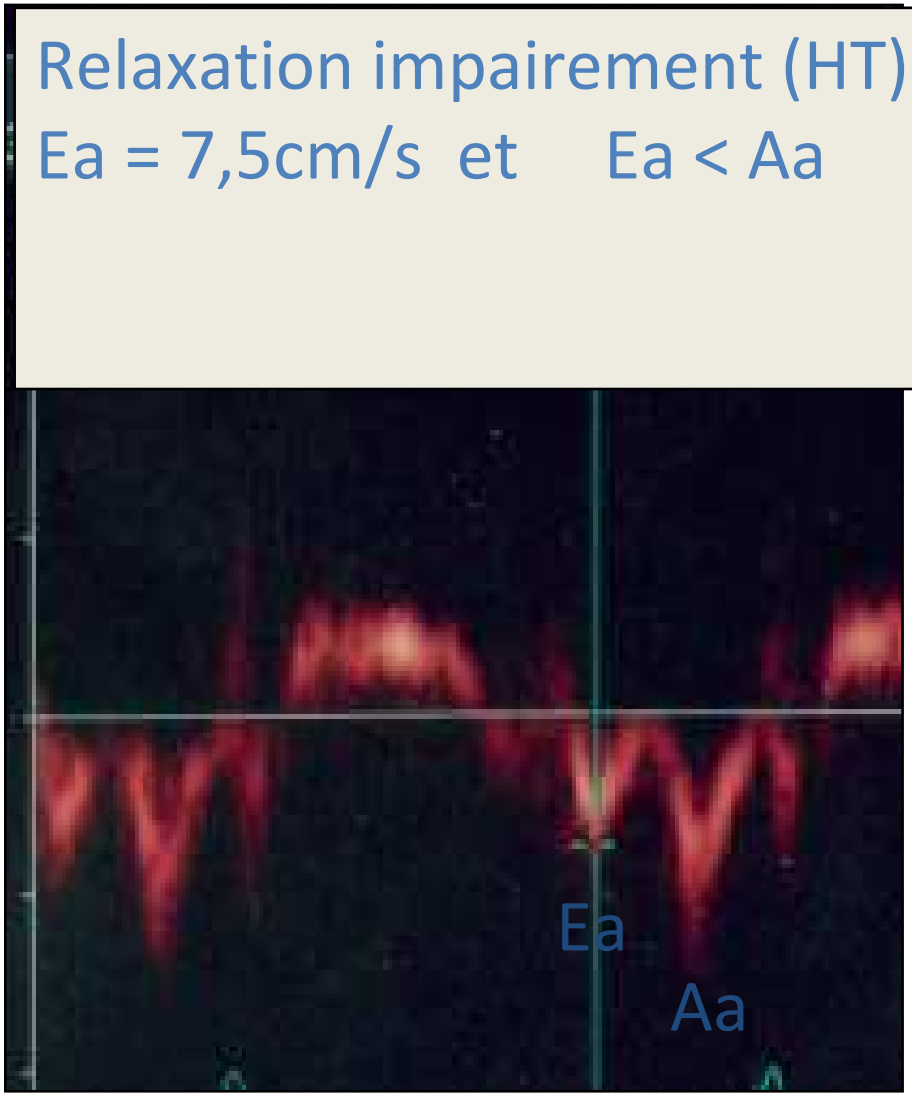
normal

Ea = 18cm/s Ea > Aa



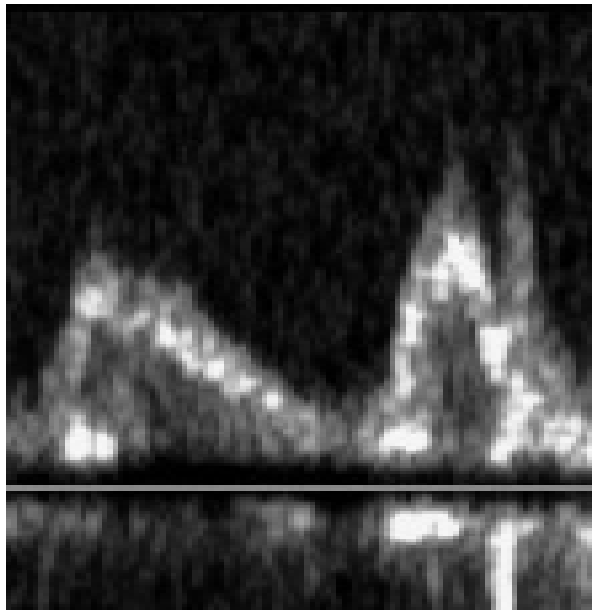
Relaxation impairement (HT)

Ea = 7,5cm/s et Ea < Aa

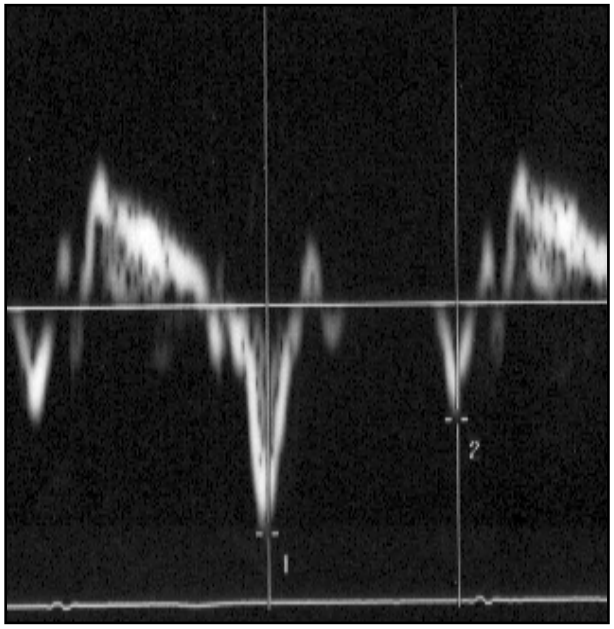


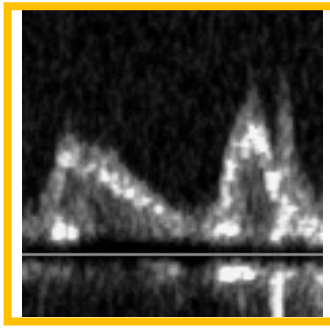
Exploration de la fonction diastolique

- Flux mitral mais dépend de la relaxation et de la précharge (PAPO)



- E’ : indépendant de la PAPO et dépend uniquement de la relaxation (et compliance) du VG

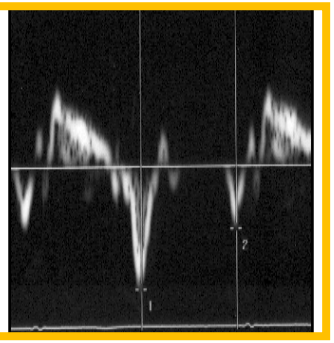


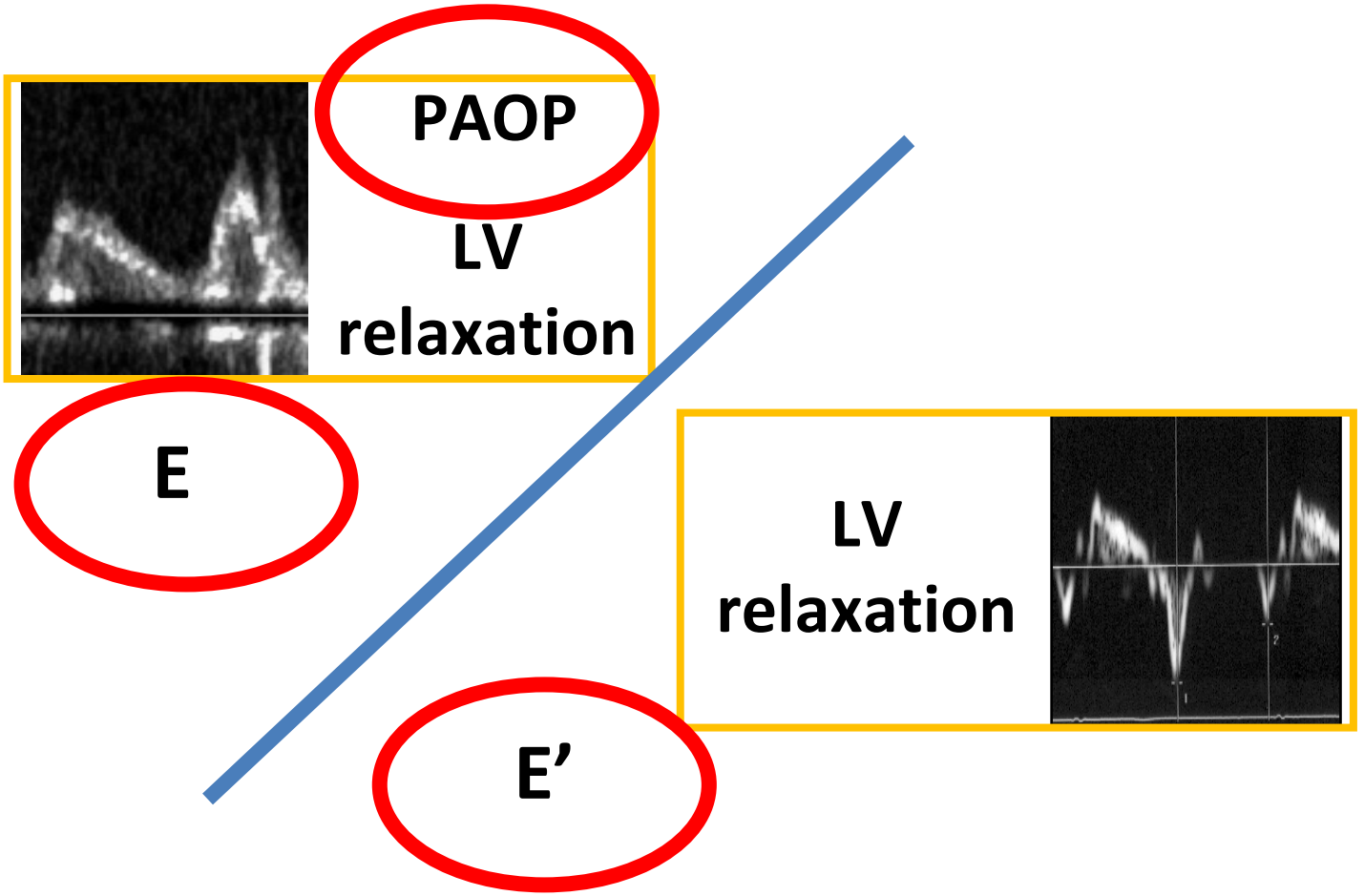


PAOP

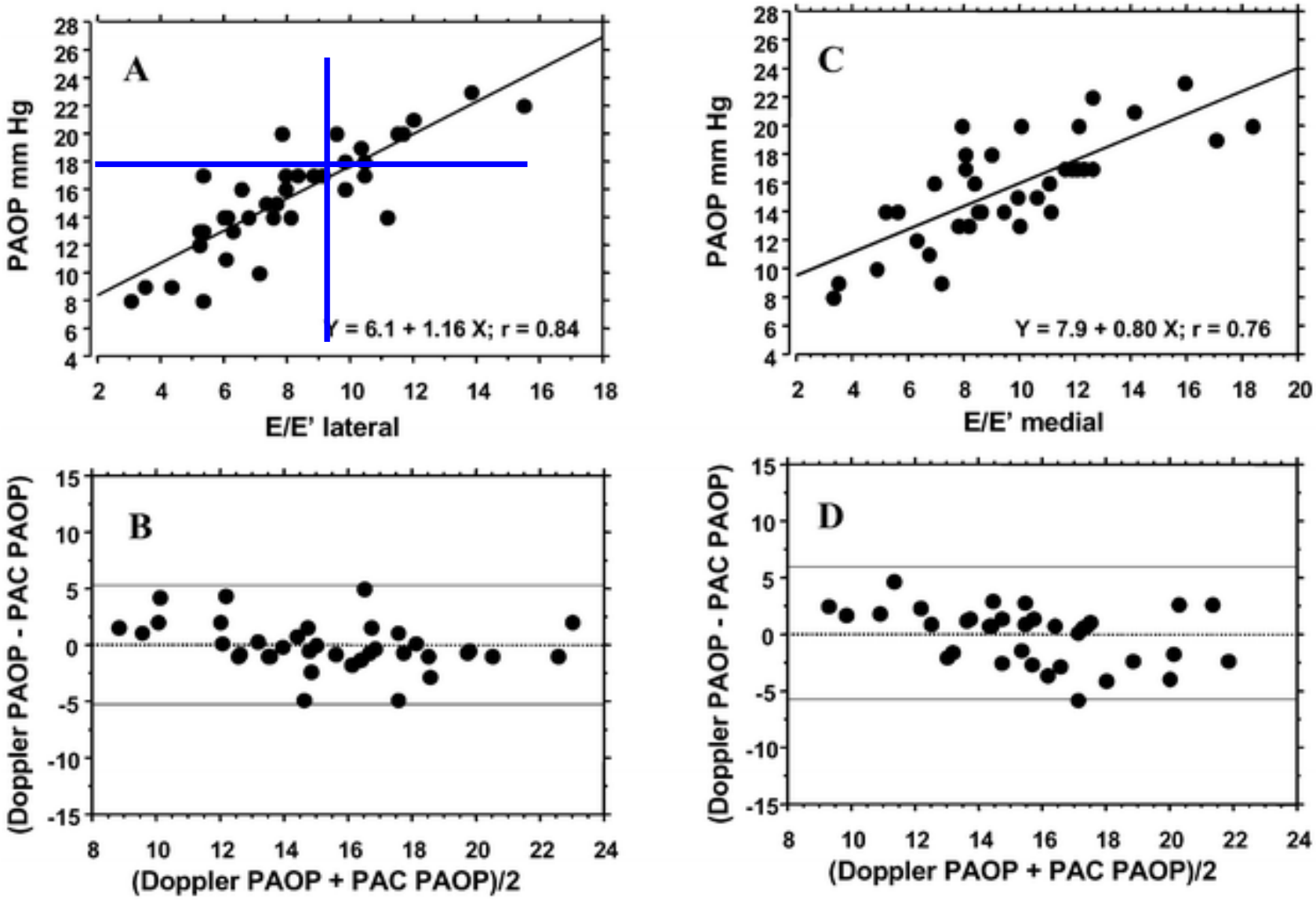
LV relaxation

LV relaxation




PAOP
LV
relaxation
E
LV
relaxation
E’

E/Ea

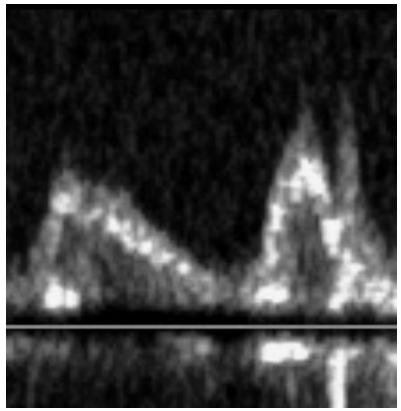


ICU, mechanical ventilation

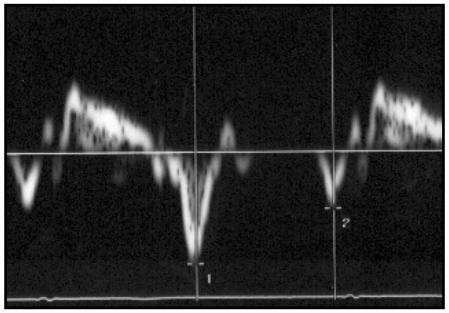
Combes A Int Care Med 2004

To assess diastolic function

Mitral flow (E wave) but depends on relaxation AND preload (PAOP)

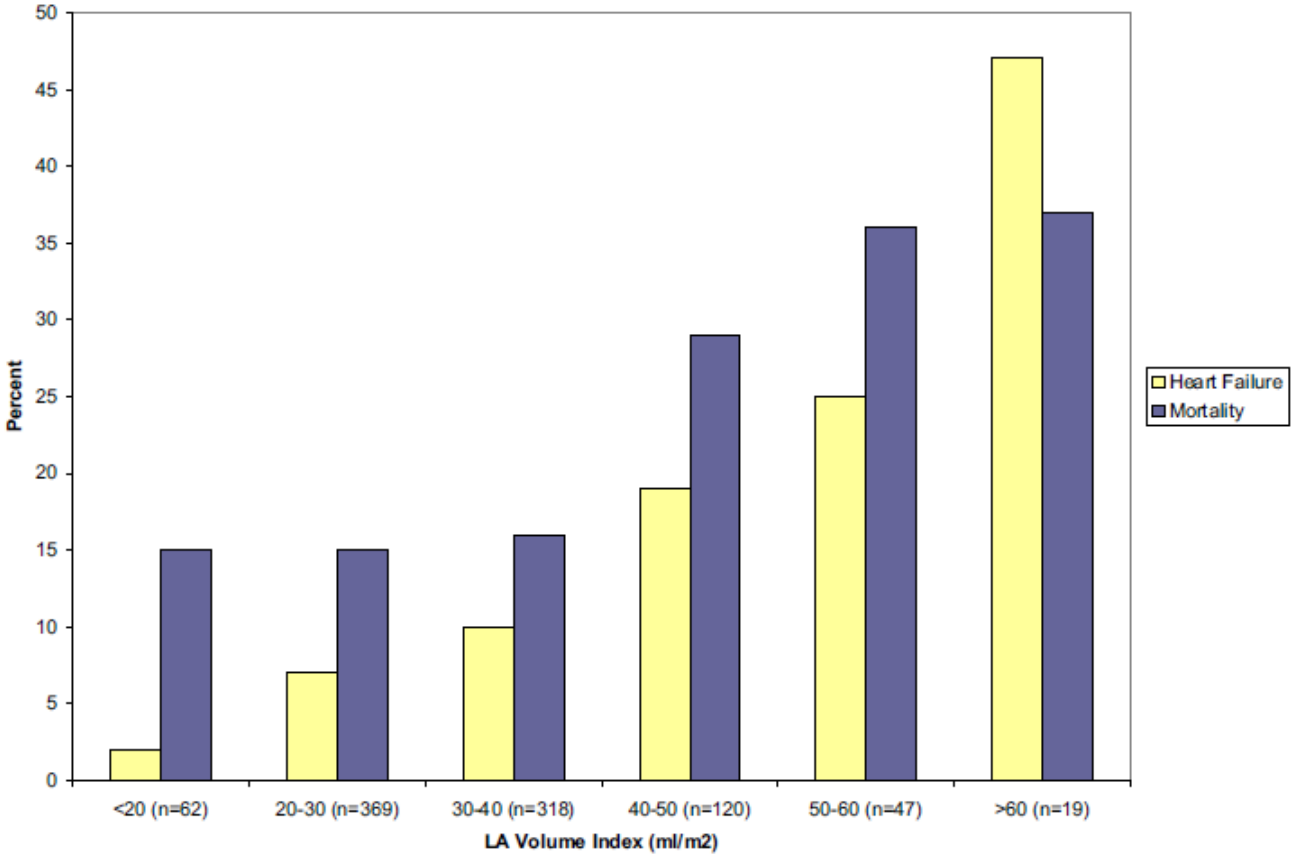


E’ : mitral annulus velocity which is independent to PAOP and depends only on LV relaxation (and compliance)

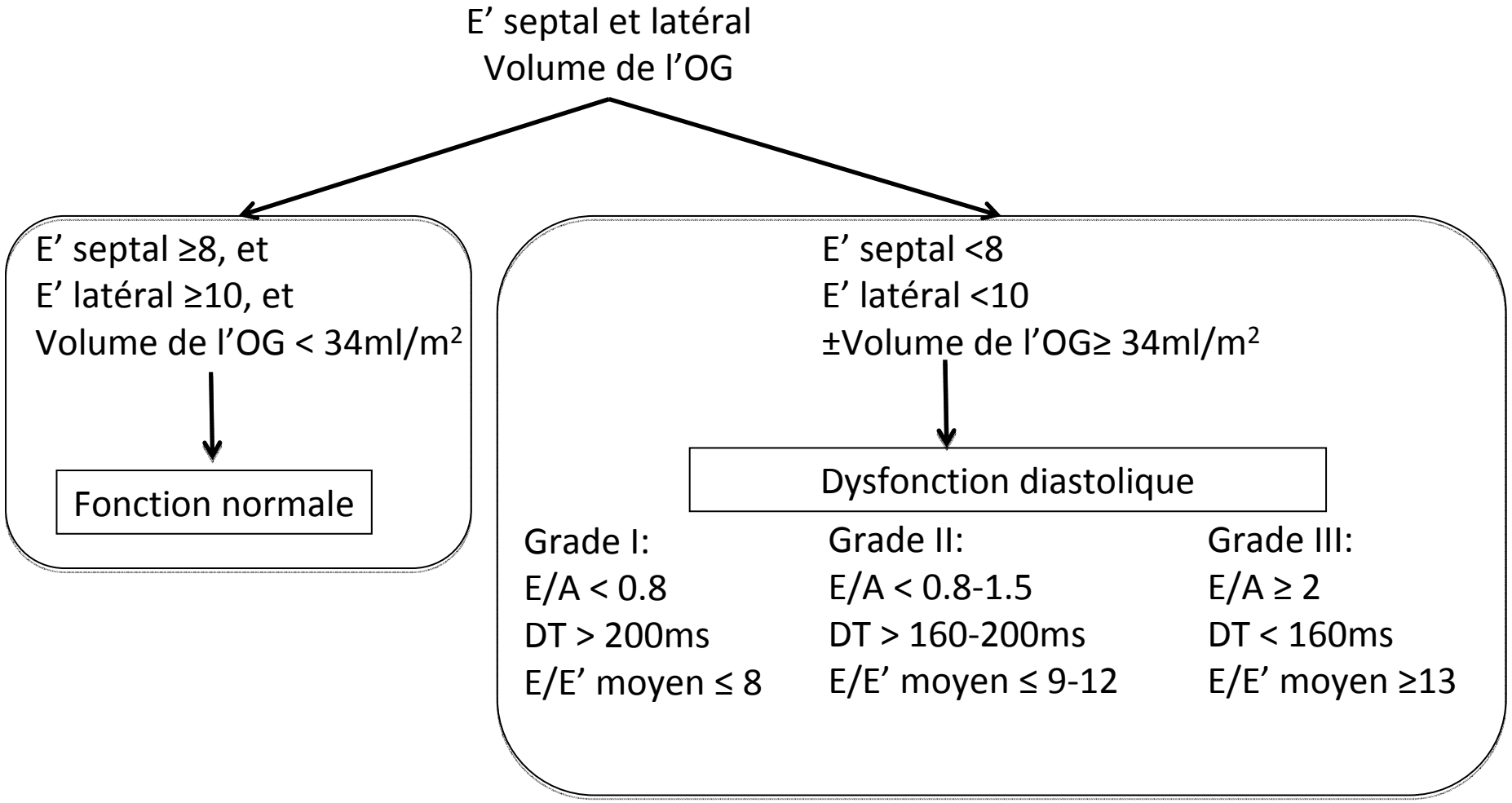


PAOP : E/E’

Taille de l'OG



Ristow Am J Cardiol 2008


E’ septal et latéral
Volume de l’OG
E’ septal ≥8, et
E’ latéral ≥10, et
Volume de l’OG < 34ml/m2
Fonction normale
E’ septal <8
E’ latéral <10
±Volume de l’OG≥ 34ml/m2
Dysfonction diastolique
Grade I:
E/A < 0.8
DT > 200ms
E/E’ moyen ≤ 8
Grade II:
E/A < 0.8-1.5
DT > 160-200ms
E/E’ moyen ≤ 9-12
Grade III:
E/A ≥ 2
DT < 160ms
E/E’ moyen ≥13

Pourquoi s'intéresser à la fonction diastolique?

- Œdème pulmonaire
- Remplissage vasculaire chez le patient hypertendu avec ou sans HVG
- Patients en choc septique
- Sevrage de la ventilation mécanique

Congestive cardiac failure with preserved systolic function

- **50% of patients with congestive heart failure**
- Increased prevalence with
  - Age
  - Hypertension

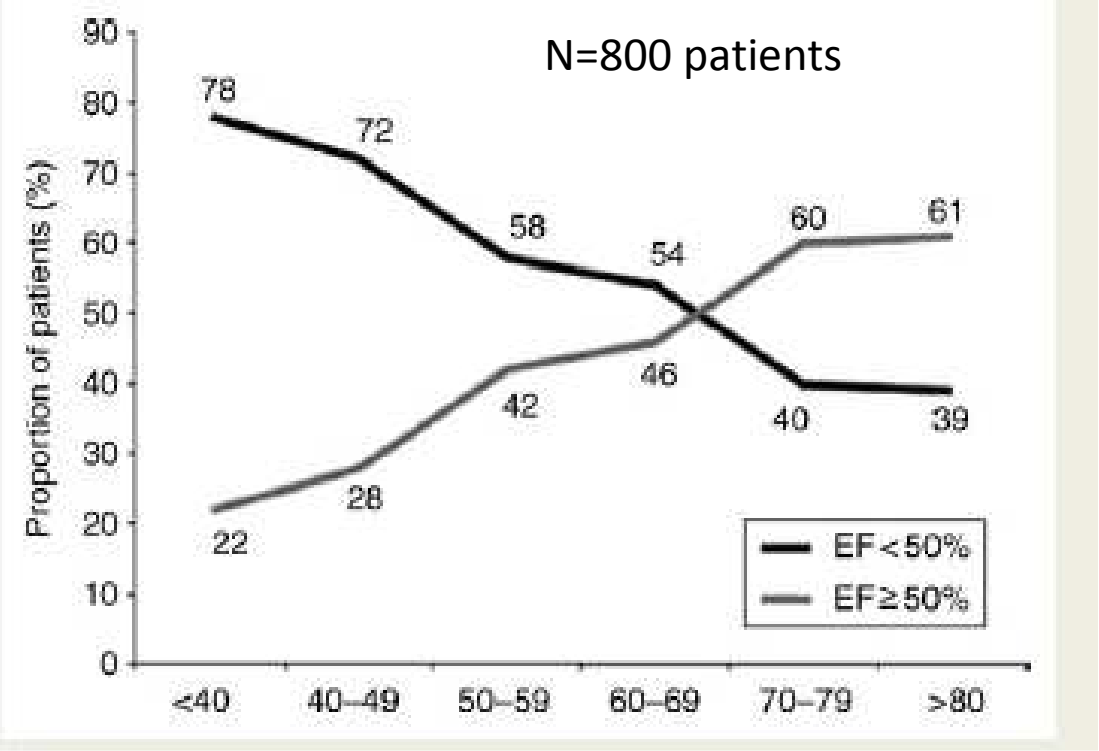
European Heart Journal (2008) **29**, 339–347
doi:10.1093/eurheartj/ehm554

CLINICAL RESEARCH
Heart failure/cardiomyopathy

Prognosis of heart failure with preserved ejection fraction: a 5 year prospective population-based study

Christophe Tribouilloy*, Dan Rusinaru, Haïfa Mahjoub, Vicky Soulière, Franck Lévy, Marcel Peltier, Michel Slama, and Ziad Massy

N=800 patients



Pourquoi s'intéresser à la fonction diastolique?

- Œdème pulmonaire
- Remplissage vasculaire chez le patient hypertendu avec ou sans HVG
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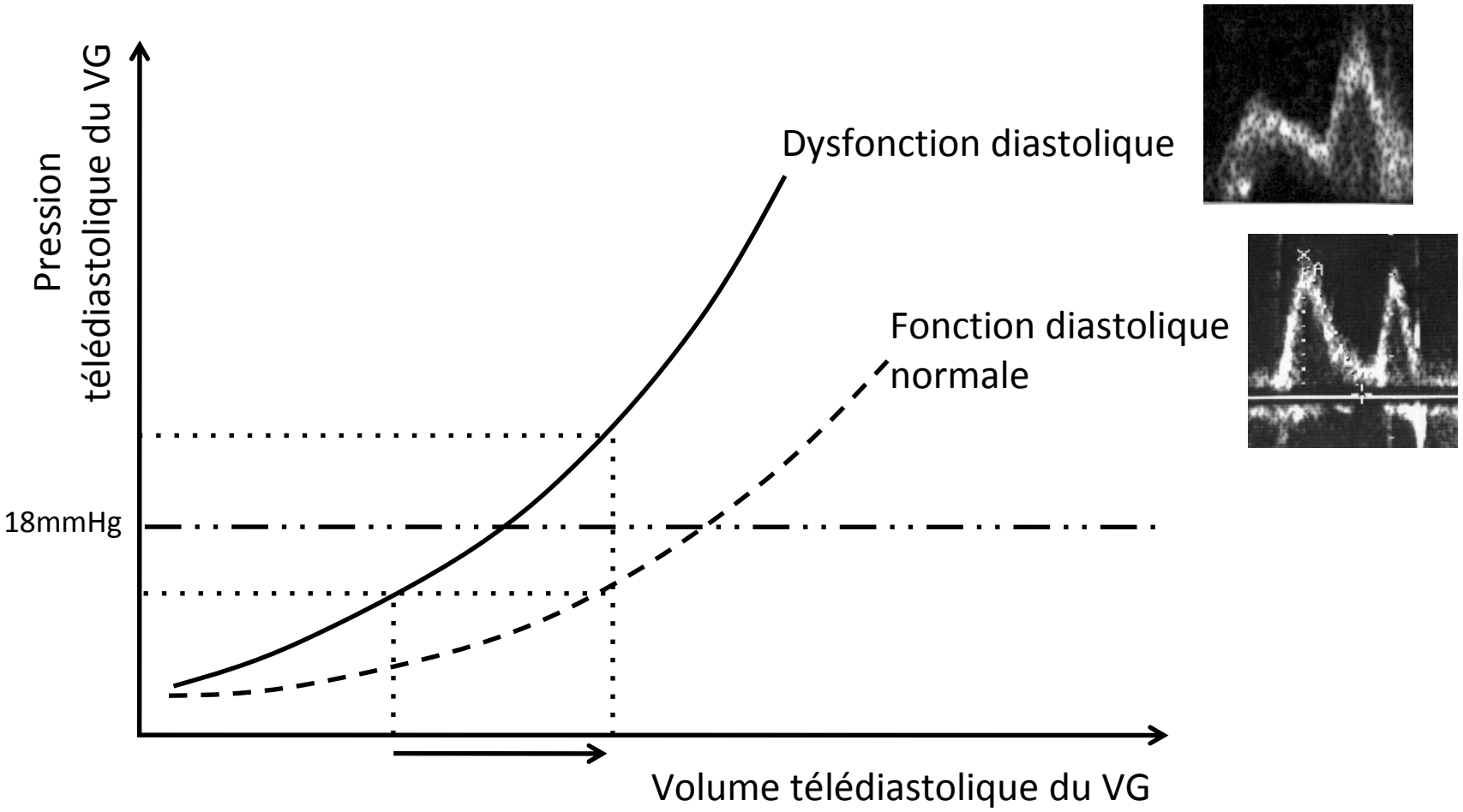
- Sevrage de la ventilation mécanique

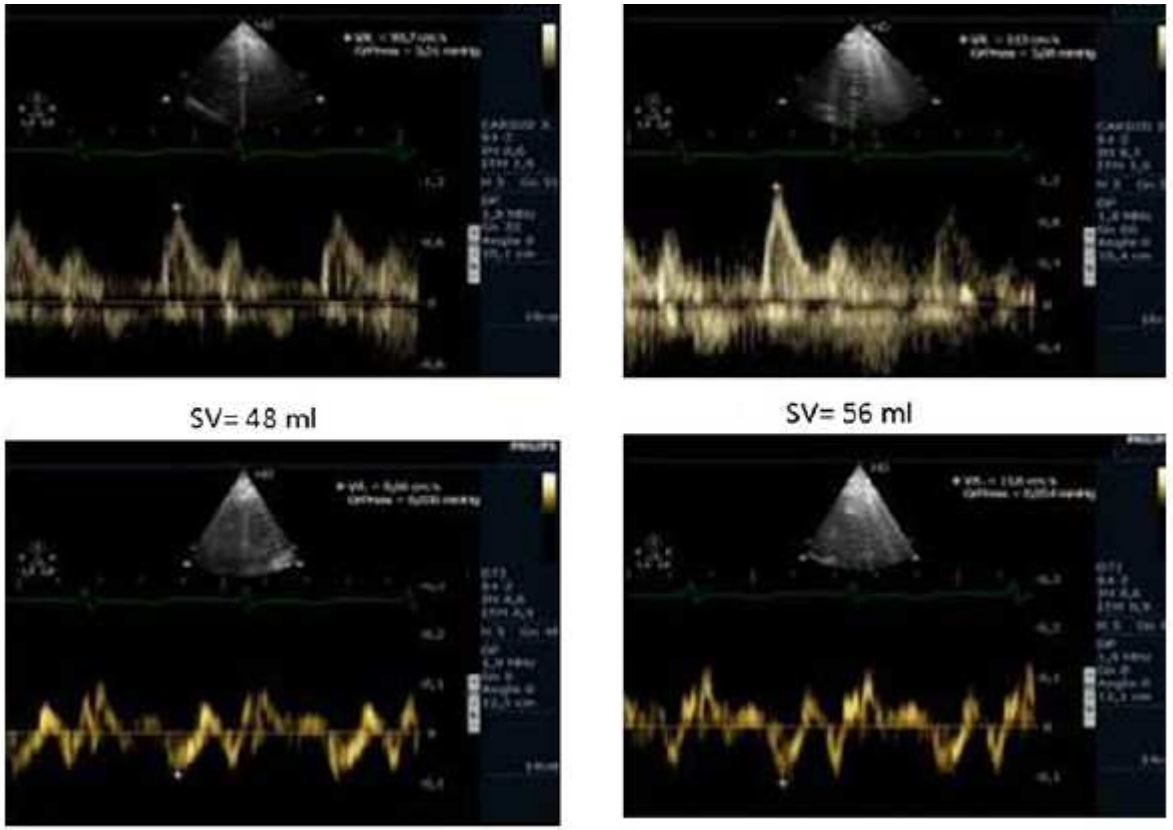

Pression
télédiastolique du VG
Dysfonction diastolique
Fonction diastolique
normale
18mmHg
Volume télédiastolique du VG

Intensive Care Med (2012) 38:1461–1470
DOI 10.1007/s00134-012-2618-9

ORIGINAL

Yazine Mahjoub
Hélène Benoit-Fallet
Norair Airapetian
Emmanuel Lorne
Mélanie Levrard
Abdoul-Aziz Seydi
Nacim Amennouche
Michel Slama
Hervé Dupont

Improvement of left ventricular relaxation as assessed by tissue Doppler imaging in fluid-responsive critically ill septic patients



Diastolic function improves after fluid infusion in septic shock patients with diastolic dysfunction

VE-induced variation in haemodynamic parameters	Responders ($n = 59$)	Non-responders ($n = 24$)	p
ΔSV % (ml)	29 ± 2 (15 ± 1)	2 ± 3 (−1 ± 1)	<0.0001
ΔCO % (l/min)	20 ± 3 (1.0 ± 0.1)	6 ± 4 (0.3 ± 0.2)	0.005
ΔLVEDA % (cm^2)	8 ± 4 (1.8 ± 0.8)	−9 ± 7 (−2.2 ± 1.2)	0.03
ΔE′ wave % (m/s)	22 ± 4 (0.020 ± 0.010)	5 ± 6 (0.007 ± 0.007)	0.02
ΔE/E′ %	8 ± 5 (0.2 ± 0.3)	28 ± 8 (1.4 ± 0.4)	0.02

Mahjoub Int Care med 2012

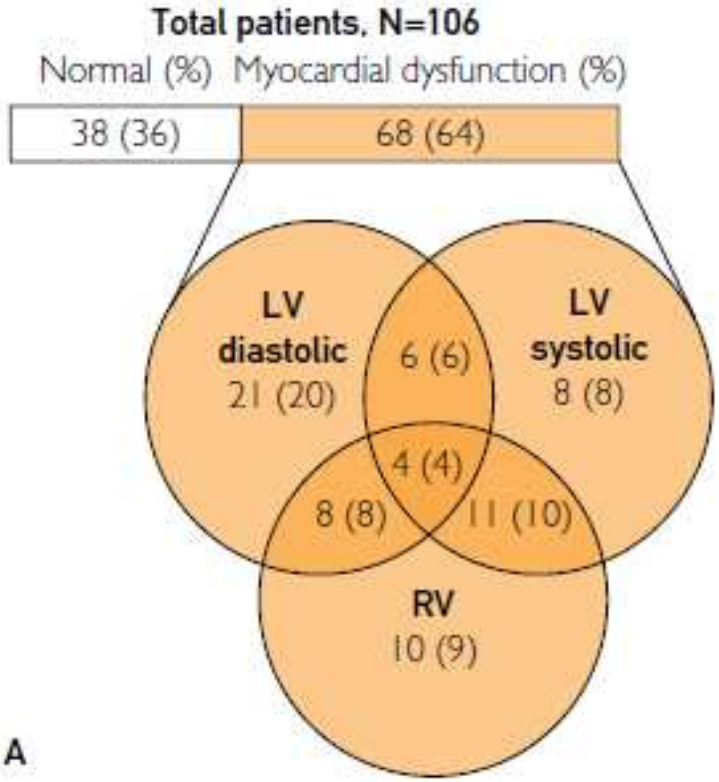
Pourquoi s'intéresser à la fonction diastolique?

- Œdème pulmonaire
- Remplissage vasculaire chez le patient hypertendu avec ou sans HVG
- Patients en choc septique
- Sevrage de la ventilation mécanique

MAYO CLINIC

Clinical Spectrum, Frequency, and Significance of Myocardial Dysfunction in Severe Sepsis and Septic Shock

Juan N. Pulido, MD; Bekele Afessa, MD; Mitsuru Masaki, MD, PhD; Toshinori Yuasa, MD, PhD; Shane Gillespie, DO; Vitaly Herasevich, MD, PhD; Daniel R. Brown, MD, PhD; and Jae K. Oh, MD

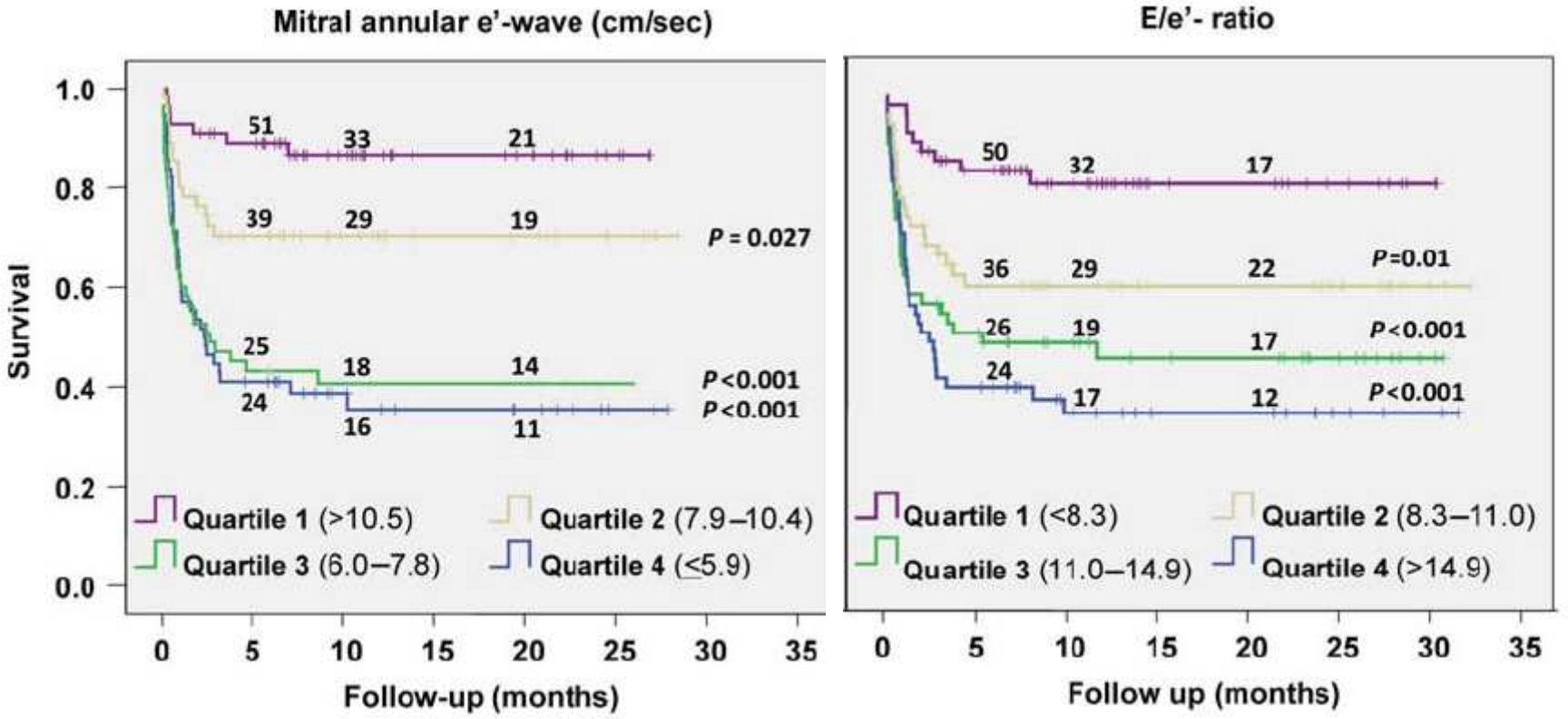


A

Mayo Clin Proc. 2012;87(7):620-628

Diastolic dysfunction and mortality in severe sepsis and septic shock

Giora Landesberg[1]*, Dan Gilon[2], Yuval Meroz[1], Milena Georgieva[1], Phillip D. Levin[1], Sergey Goodman[1], Alexander Avidan[1], Ronen Beeri[2], Charles Weissman[1], Allan S. Jaffe[3], and Charles L. Sprung[1]



European Heart Journal (2012) **33**, 895–903

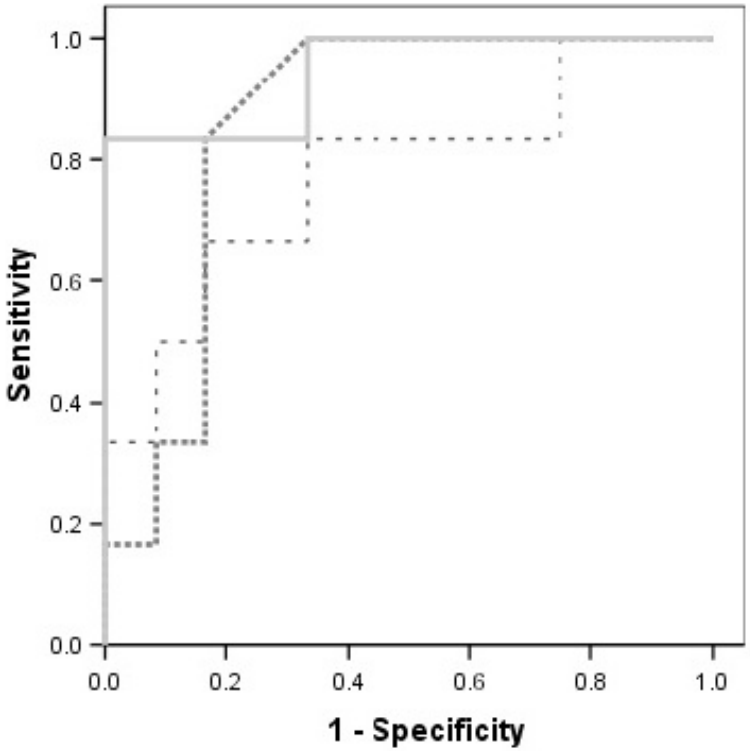
Sturgess et al. Critical Care 2010, 14:R44
http://ccforum.com/content/14/2/R44

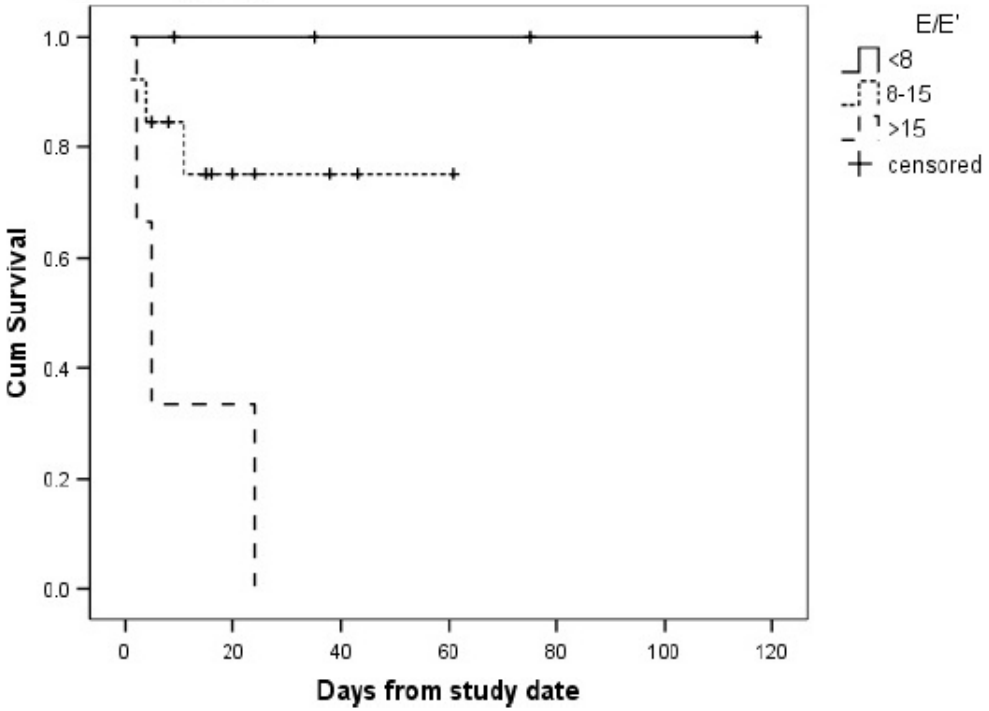
CRITICAL CARE

RESEARCH Open Access

Prediction of hospital outcome in septic shock: a prospective comparison of tissue Doppler and cardiac biomarkers

David J Sturgess[1,2*], Thomas H Marwick[1,3], Chris Joyce[1,4], Carly Jenkins[1,3], Mark Jones[5], Paul Masci[1], David Stewart[4], Bala Venkatesh[1,2,4]





Pourquoi s'intéresser à la fonction diastolique?

- Œdème pulmonaire
- Remplissage vasculaire chez le patient hypertendu avec ou sans HVG
- Patients en choc septique
- Pression intra abdominale
- Sevrage de la ventilation mécanique

British Journal of Anaesthesia **108** (2): 211–15 (2012)
Advance Access publication 8 December 2011 · doi:10.1093/bja/aer382

BJA

Effect of intra-abdominal hypertension on left ventricular relaxation: a preliminary animal study

Y. Mahjoub[1,2*], E. Lorne[1,2], J. Maizel[2,3], G. Plantefève[4], Z. A. Massy[2,5], H. Dupont[1,2] and M. Slama[2,3]

	Baseline	IAH (baseline + 20 mm Hg)	*P*-value
HR (bpm)	202 [152–252] (150–255)	166 [116–216] (115–220)	0.60
MAP (mm Hg)	60 [45–75] (44–76)	50 [38–67] (36–70)	0.20
SAP (mm Hg)	72 [61–83] (60–85)	83 [60–103] (58–105)	0.15
DAP (mm Hg)	48 [43–52] (35–60)	41 [30–56] (30–58)	0.45
$dLVP_{max}/dt$ (mm Hg s^{-1})	3590 [3463–3717] (3405–3750)	2111 [2011–2211] (2020–2225)	0.14
Tau (ms)	16 [14–18] (13–19)	43 [34–52] (31–55)	0.048
LVEDP (mm Hg)	7 [6–8] (5–9)	15 [11–19] (10–20)	0.04
CVP (mm Hg)	2 [−2 to 6] (−1 to 7)	7 [−2 to 12] (−1 to 13)	0.03
Plateau pressure (cm H_2O)	23 [18–28] (17–29)	34 [27–42] (25–43)	0.04
Oesophageal pressure (cm H_2O)	2.8 [1.5–4] (1–5)	3.9 [2–4.5] (1.5–5)	0.22

Pourquoi s'intéresser à la fonction diastolique?

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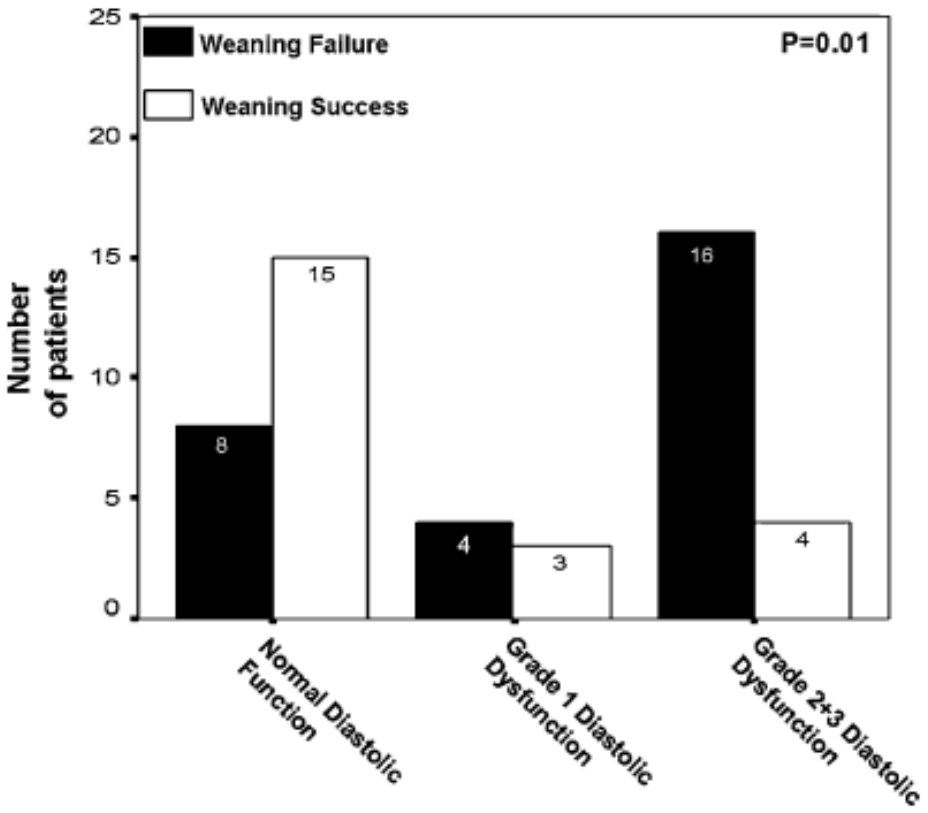
- Sevrage de la ventilation mécanique

Pre SBT

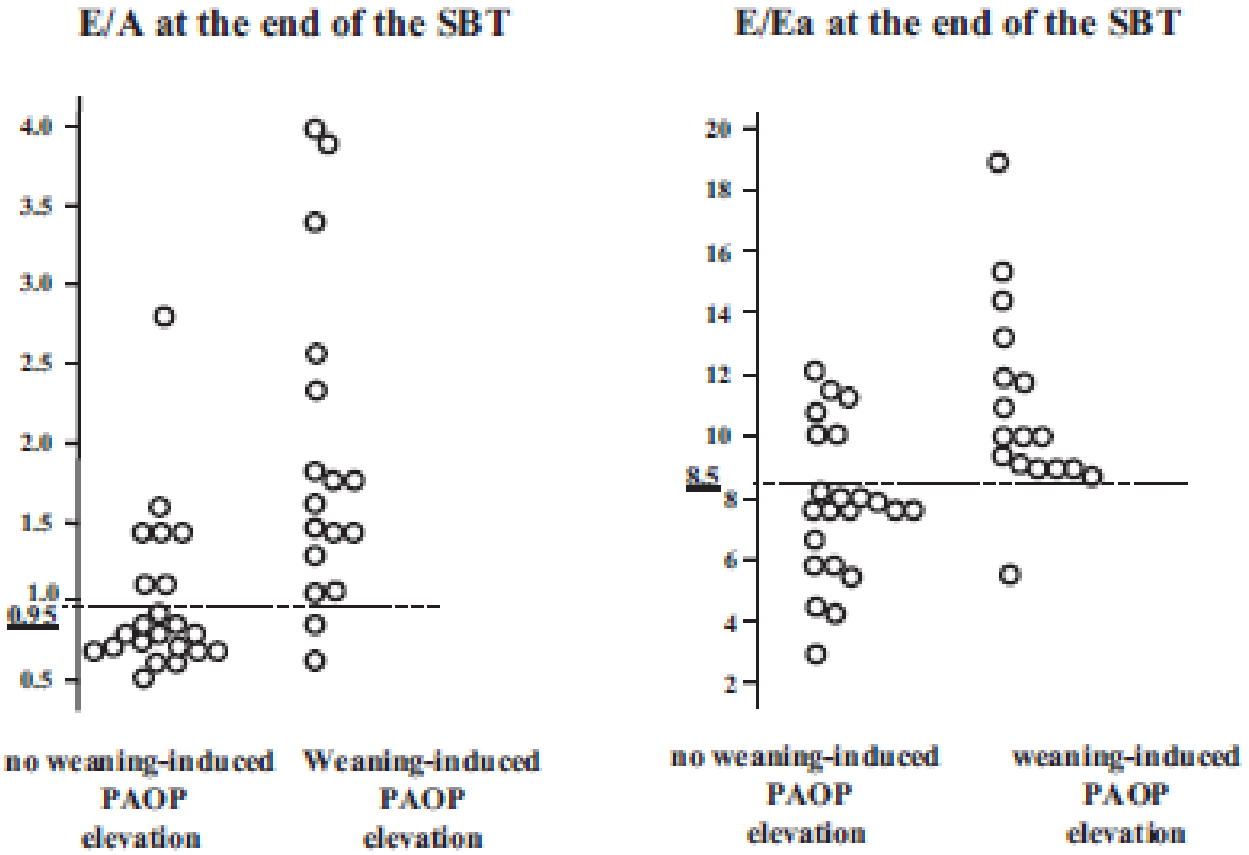


Papanikolaou Int Care Med 2011

Echocardiographic diagnosis of pulmonary artery occlusion pressure elevation during weaning from mechanical ventilation*

Bouchra Lamia, MD, MPH, PhD; Julien Maizel, MD; Ana Ochagavia, MD; Denis Chemla, MD, PhD; David Osman, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

PAOP>18 mmHg



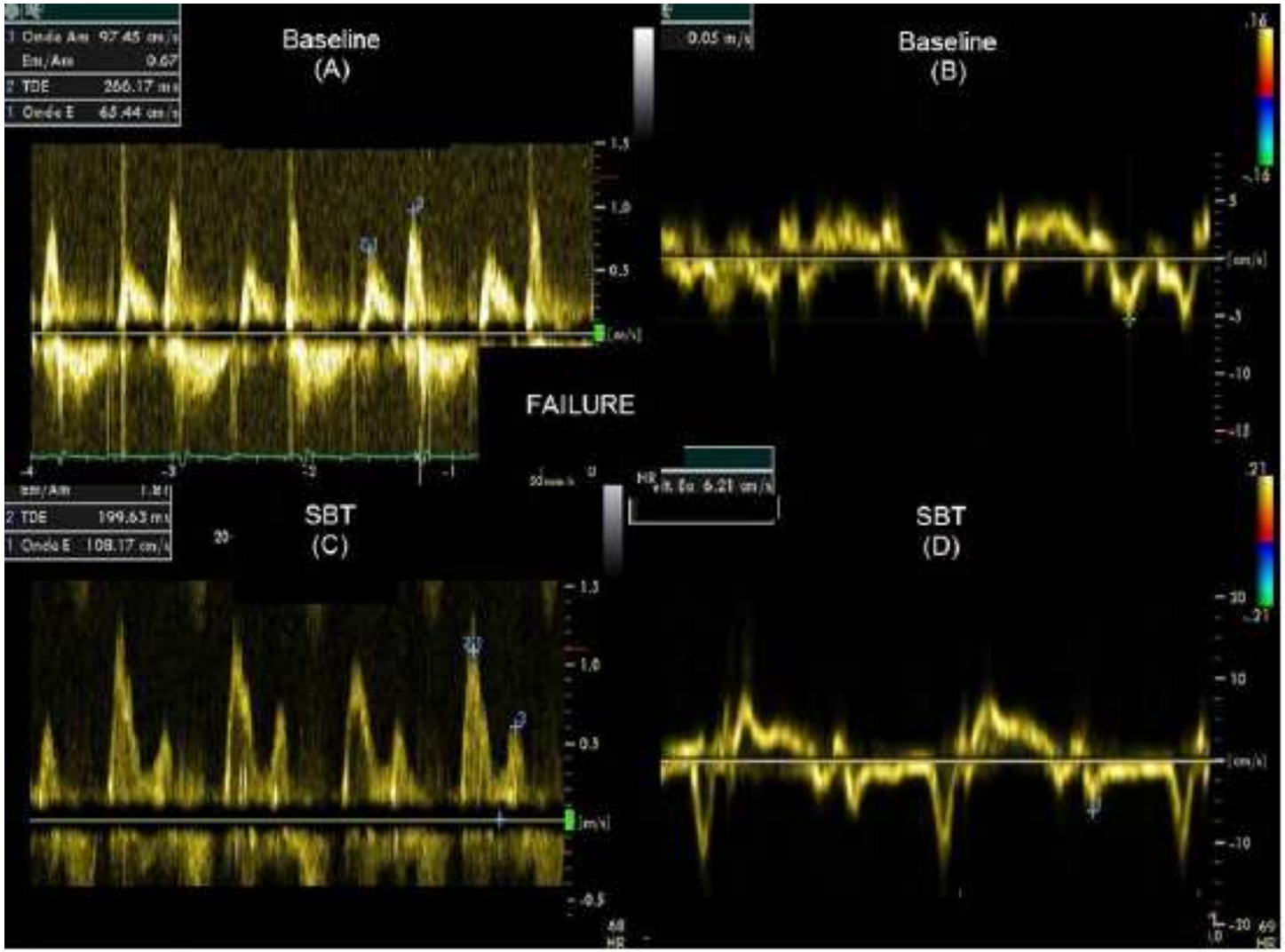
Lamia Crit care med 2009

	Weaning success	
	Baseline	End-SBT
NT-proBNP, pg/mL	3972 (1339-7751)	3952 (1531-7928)
LVEF (%)	40.5 (34-50)	45 (35-51) [a]
Cardiac index (L/min/m²)	3.0 (2.68-3.3)	3.3 (3.06-3.77) [a]
E/A ratio	1.12 (0.9-2.4)	1.24 (0.83-2.21)
E/Ea ratio	9.5 (7-15.7)	9.3 (6.8-11.9)

Gerbeaux Minerva Anesth 2012

	Weaning failure	
	Baseline	End-SBT
NT-proBNP, pg/mL	4200 (1855-7125)	8199 (3106-10949) [a,b]
LVEF (%)	39 (35-40.5)	38 (35-42)
Cardiac index (L/min/m²)	2.75 (2.43-2.9)	2.4 (2.22-2.74) [b]
E/A ratio	1.06 (0.9-1.37)	1.38 (0.93-2.15) [a]
E/Ea ratio	10.7 (6.7-20.5)	16.8 (8.5-27.3) [a,b]
Mitral regurgitation		
Absence	4	4
Mild	3	2
Moderate	2	1
Severe	1	3
RJA/LAA ratio (%, all patients)	7.7 (0-24.2)	11.0 (0-42.1) [a]
RJA/LAA ratio (%, RJA present)	17.9 (11-25.2)	30.0 (10.8-44.4) [a]

Gerbeaux Minerva Anesth 2012



Moschietto Crit care 2012

Conclusions

- Physiologie complexe de la diastole
- Ne pas négliger en réanimation cette fonction cardiaque essentielle
- Connaître les implications cliniques et les techniques d’exploration de la fonction diastolique en réanimation