

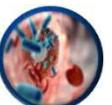
# DIU TUSAR

Bordeaux – Mardi 16 décembre 2025

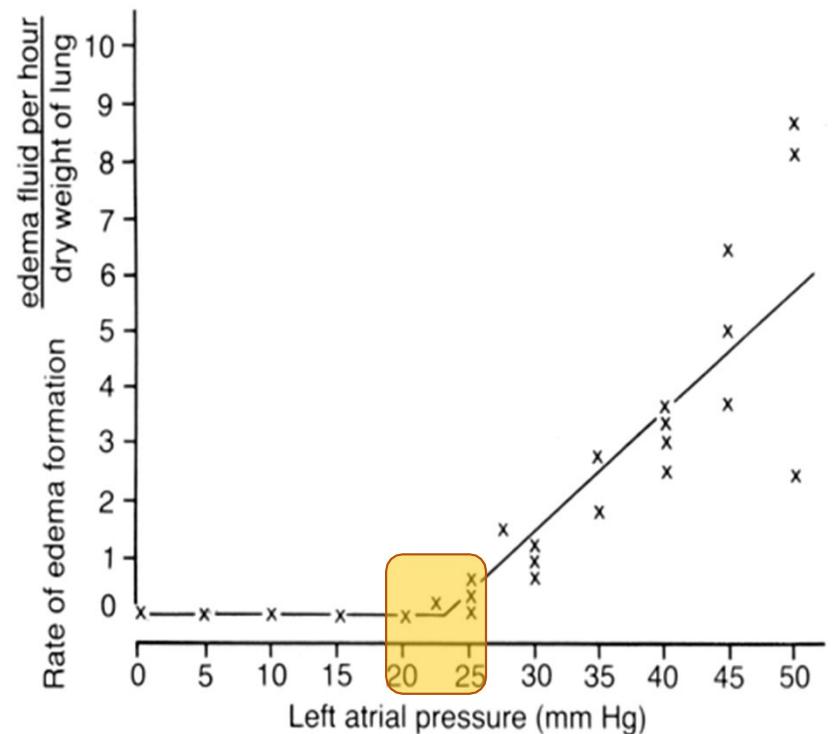
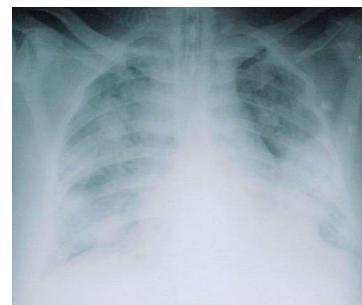
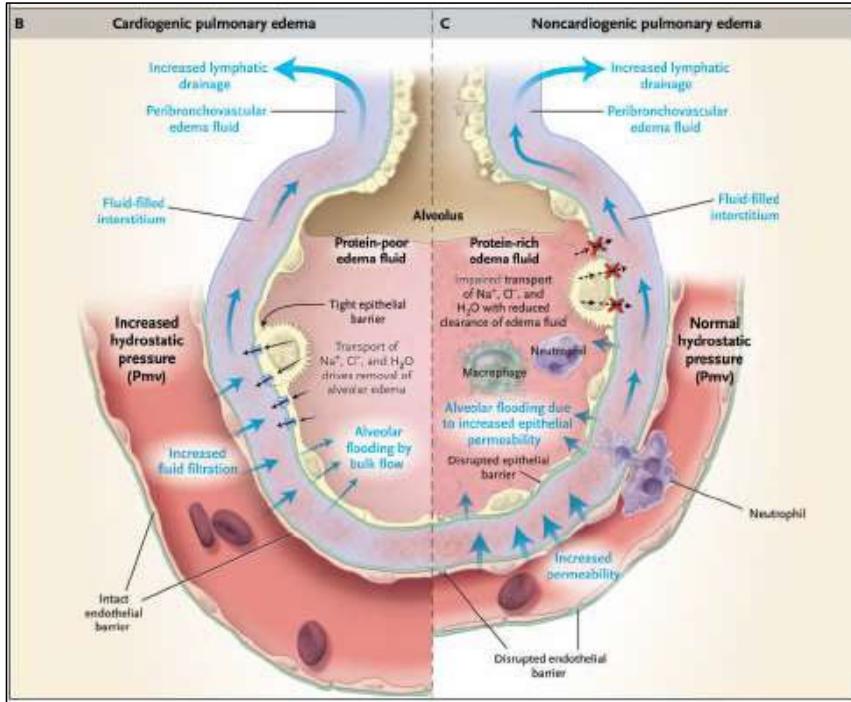
## Fonction diastolique et pressions de remplissage du ventricule gauche

Philippe Vignon

Réanimation Polyvalente  
Inserm CIC 1435  
CHU Limoges



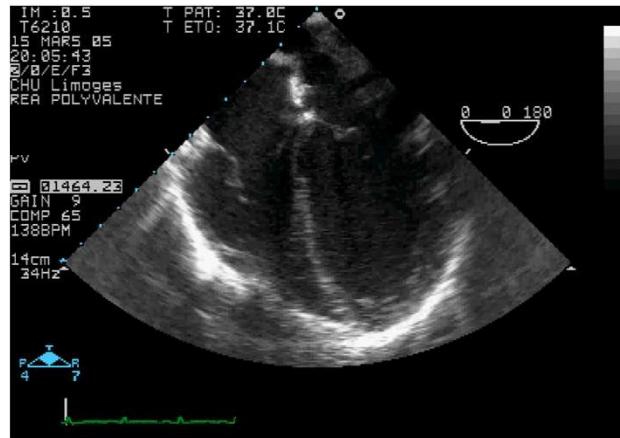
## OAP cardiogénique vs. lésionnel



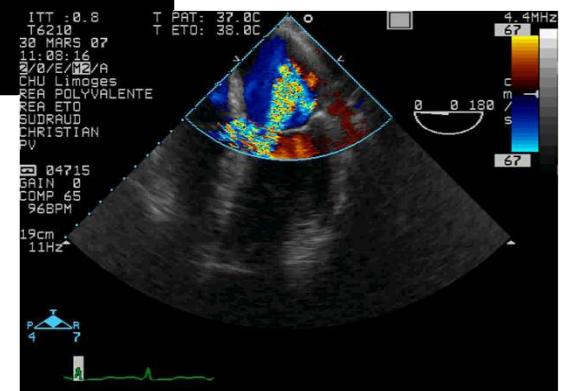
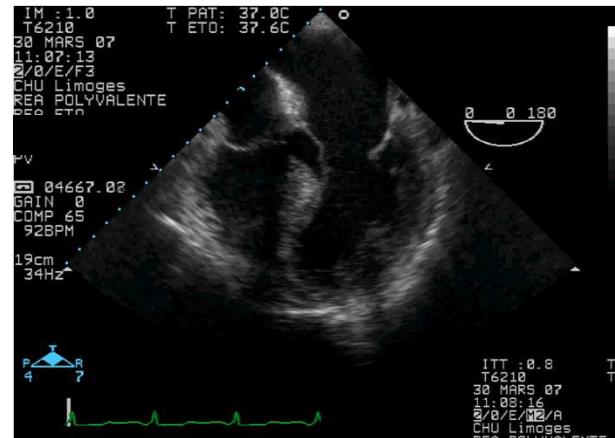
Ware LB et al N Engl J Med 2005; 353: 2788-96

Guyton, 1959

## SDRA et choc septique : Dysfonction systolique VG



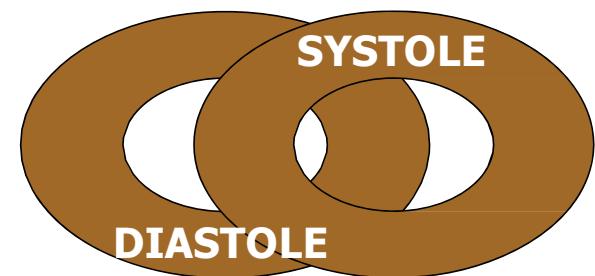
## OAP cardiogénique : Fonction systolique VG normale



La fonction systolique VG n'est PAS discriminante pour le diagnostic d'OAP cardiogénique

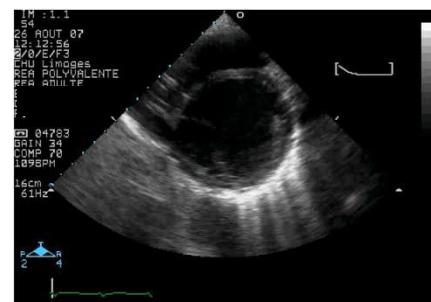
## (Dys)fonction diastolique

- ❖ Fonction diastolique **normale** : capacité du VG à se remplir jusqu'à atteindre un volume téldiastolique normal, au repos et à l'exercice, **sans élévation** de la pression auriculaire gauche (< 12 mmHg)
- ❖ **Dysfonction diastolique** : **allongement** de la **relaxation** (active) du VG souvent associée à une **diminution** de sa **compliance** (passive), notamment en cas de dysfonction systolique sévère.



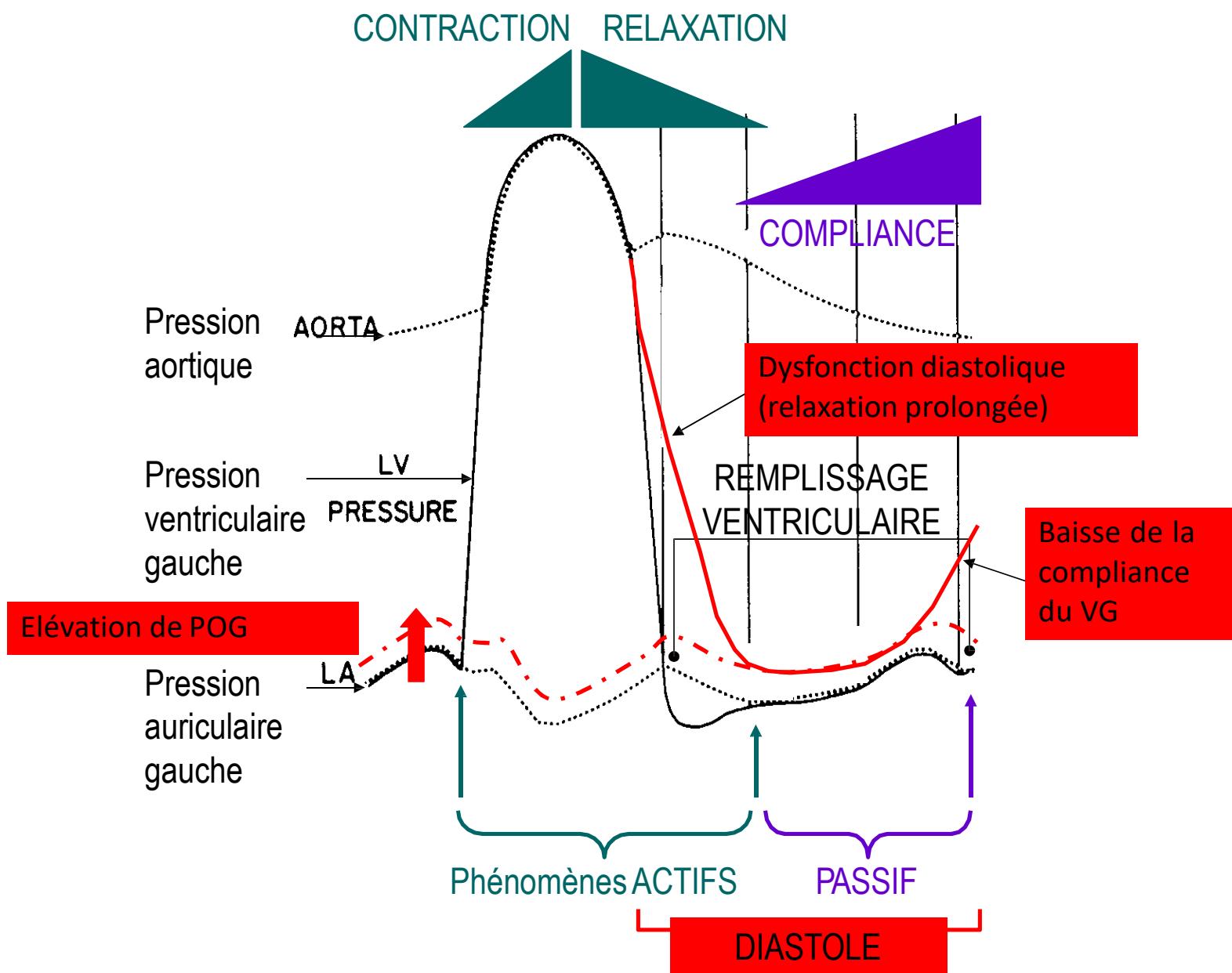
Hypertrophie

Ischémie

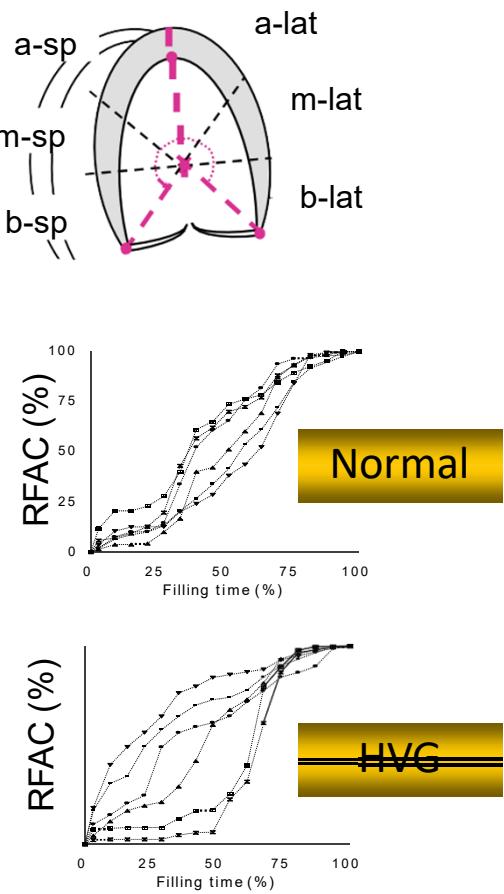


FEVG conservée

FEVG diminuée



Quantitative Evaluation of Global and Regional Left Ventricular Diastolic Function With Color Kinesis  
Philippe Vignon, Victor Mor-Avi, Lynn Weinert, Rick Koch, Kirk T. Spencer and Roberto M. Lang  
*Circulation* 1998;97:1053-1061



# Rôle accru de la contribution OG au remplissage VG

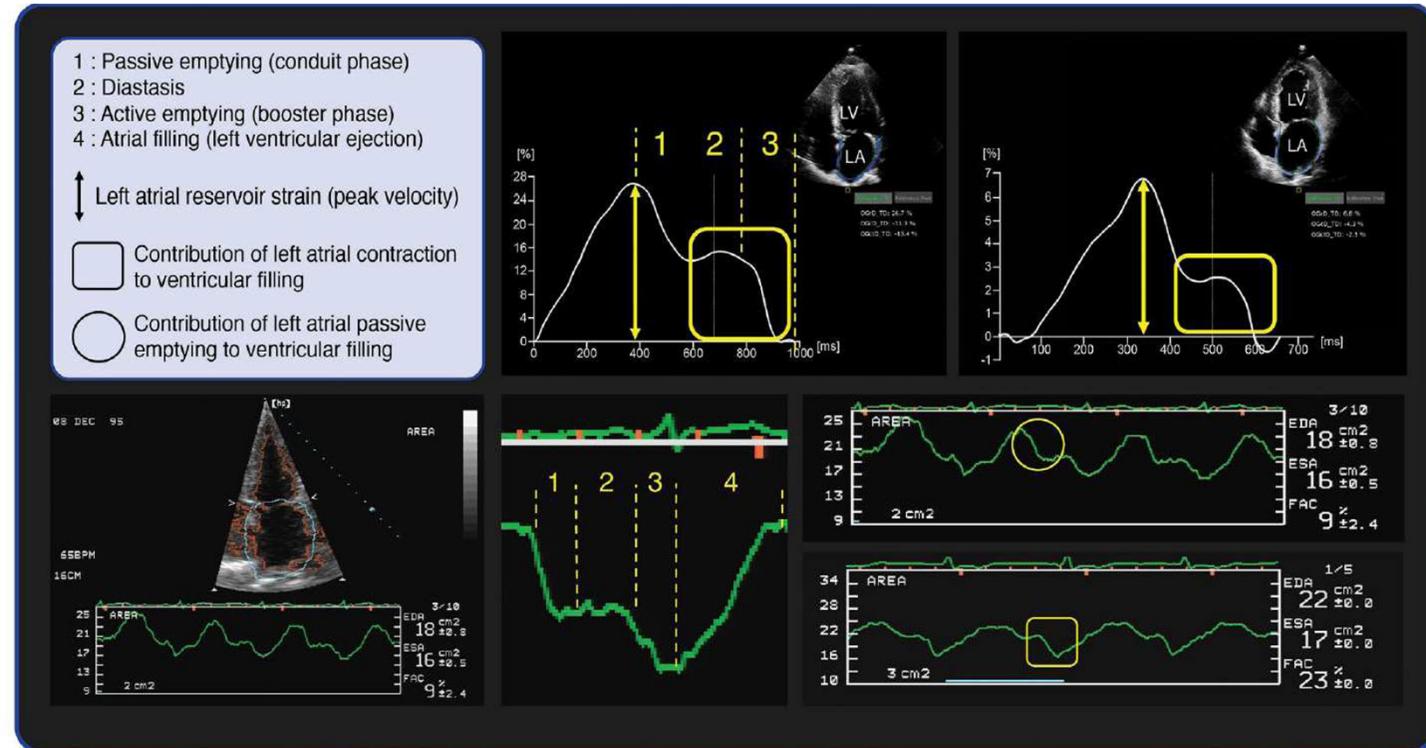
Intensive Care Med  
<https://doi.org/10.1007/s00134-025-07871-8>

## CORRESPONDENCE

Left atrial reservoir strain: an essential tool for evaluating left ventricular diastolic dysfunction in 2025—response. Authors' reply



Philippe Vignon<sup>1,2,3</sup>, Julien Vaidie<sup>1,2</sup>, Marine Goudelin<sup>1,2</sup> and Bruno Evrard<sup>1,2</sup>





## Dysfonction diastolique du VG

- ❖ Atteinte hétérogène du VG
- ❖ Conséquence 1 : élévation des pressions de remplissage du VG
- ❖ Conséquence 2 : augmentation de la contribution de l'OG au remplissage du VG

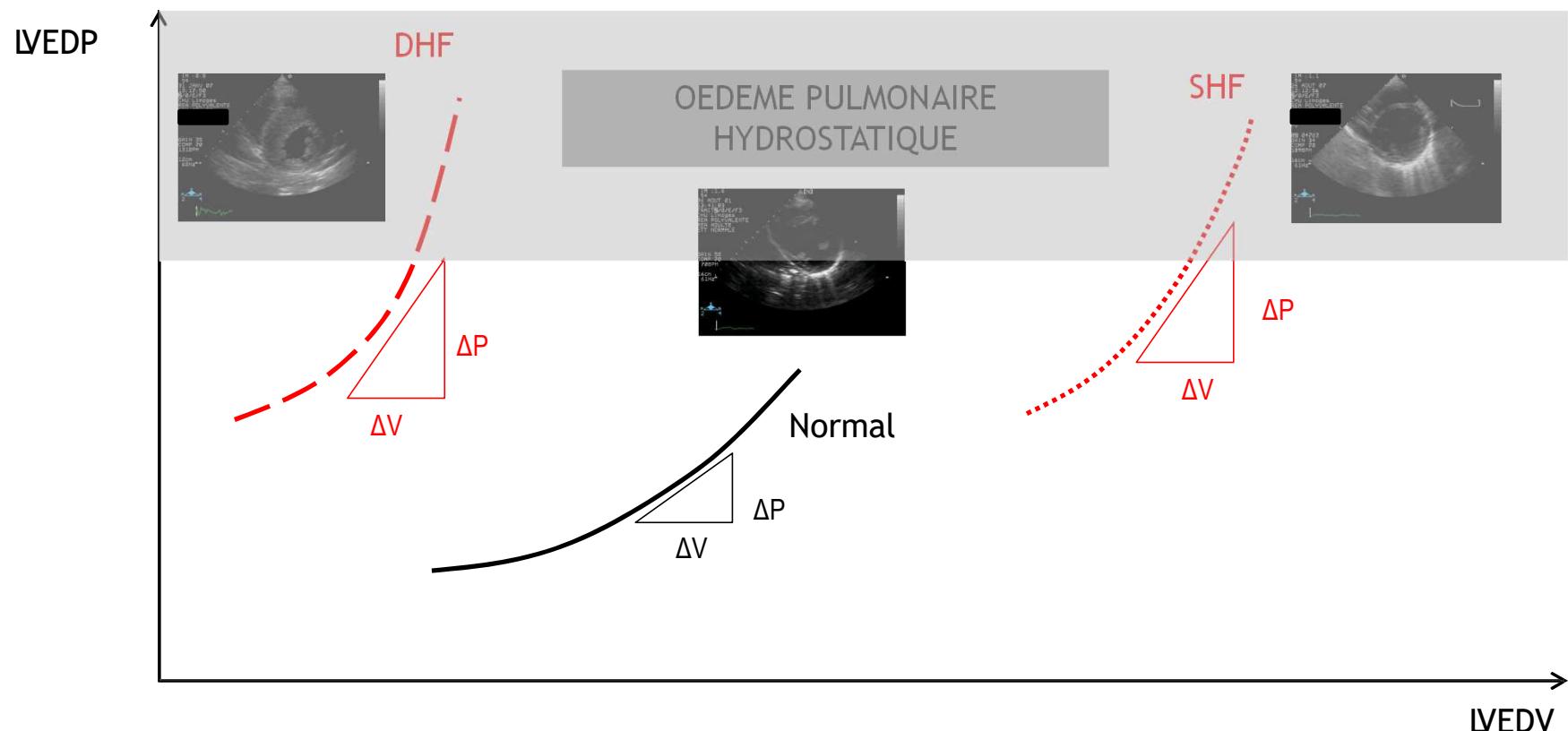


Propriétés diastoliques du VG et pressions de remplissage du VG sont donc intimement intriquées



L'OG augmente sa contraction puis se dilate et défaillie

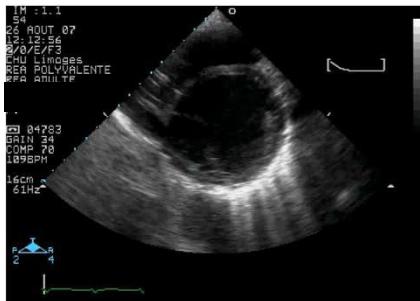
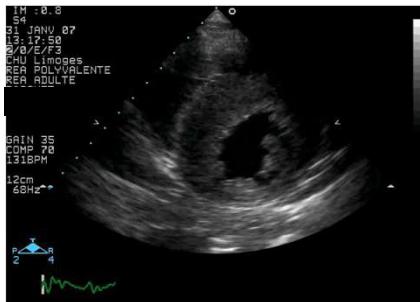
## Risque : OAP hydrostatique / cardiogénique



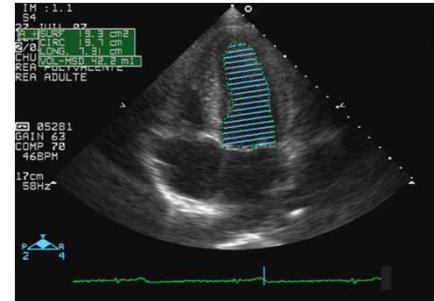
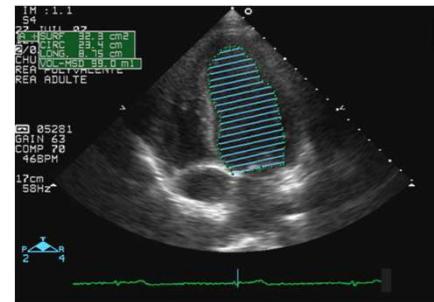


# Echocardiographie bidimensionnelle

Identification de la cardiopathie gauche responsable



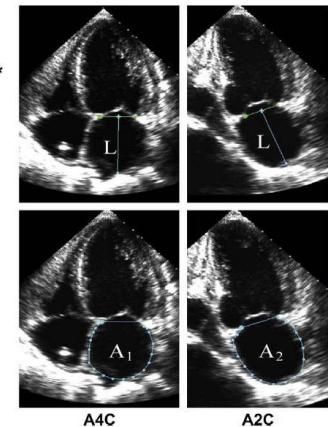
FEVG conservée ou diminuée



Dilatation de l'OG

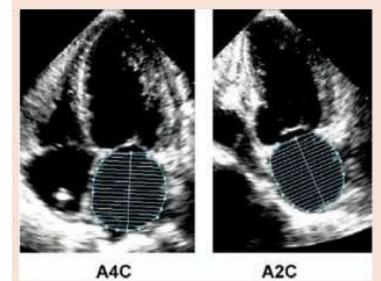
$$\text{Left Atrial Volume} = \frac{8}{3}\pi[(A_1)(A_2)/(L)]^*$$

\* (L) is the shortest of either the A4C or A2C length



Dilatation OG:  
volume  
 $> 34 \text{ mL/m}^2$

Biplane method of disks

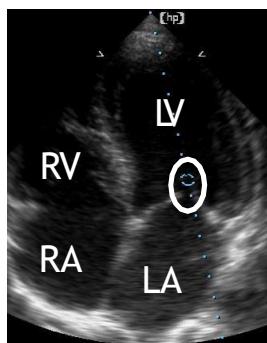




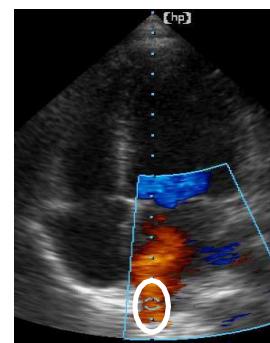
# Doppler pulsé

## Remplissage du cœur gauche

Mitral Doppler

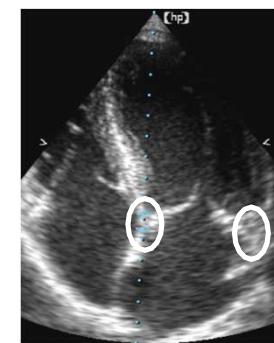


Pulmonary vein Doppler

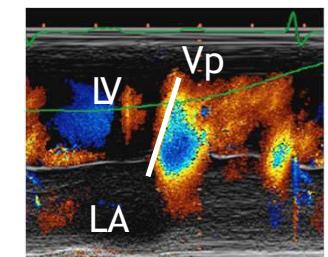
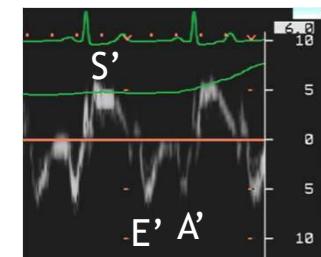
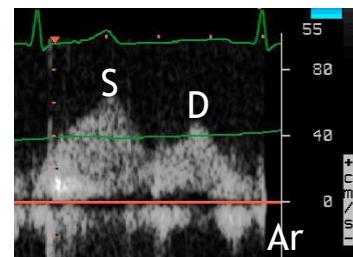
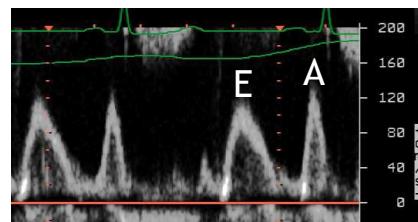
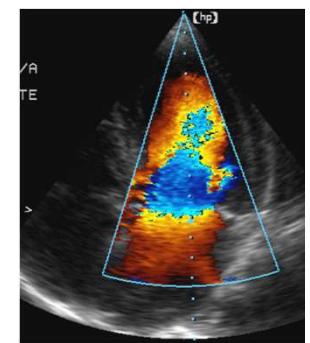


## Relaxation

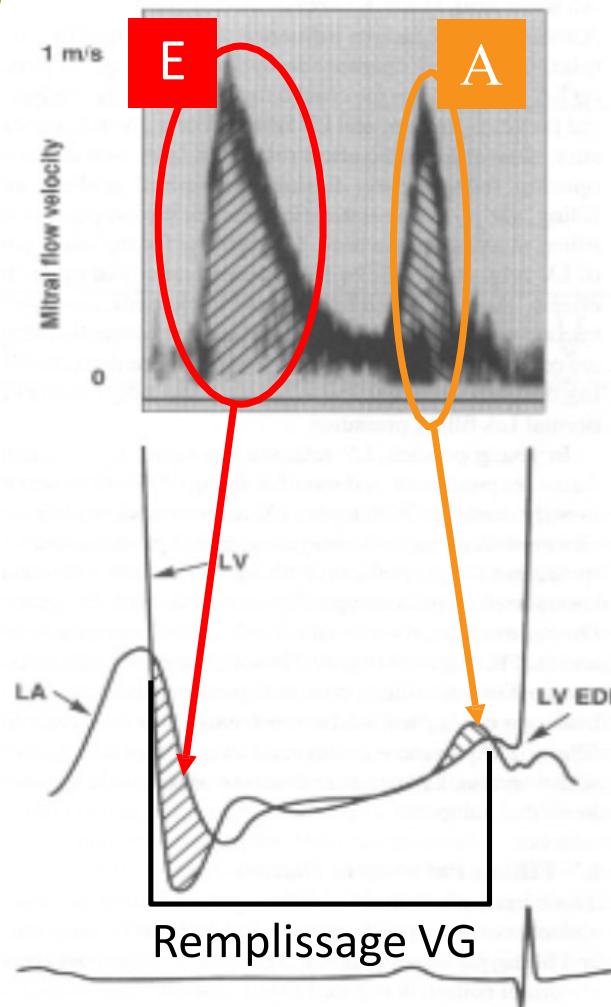
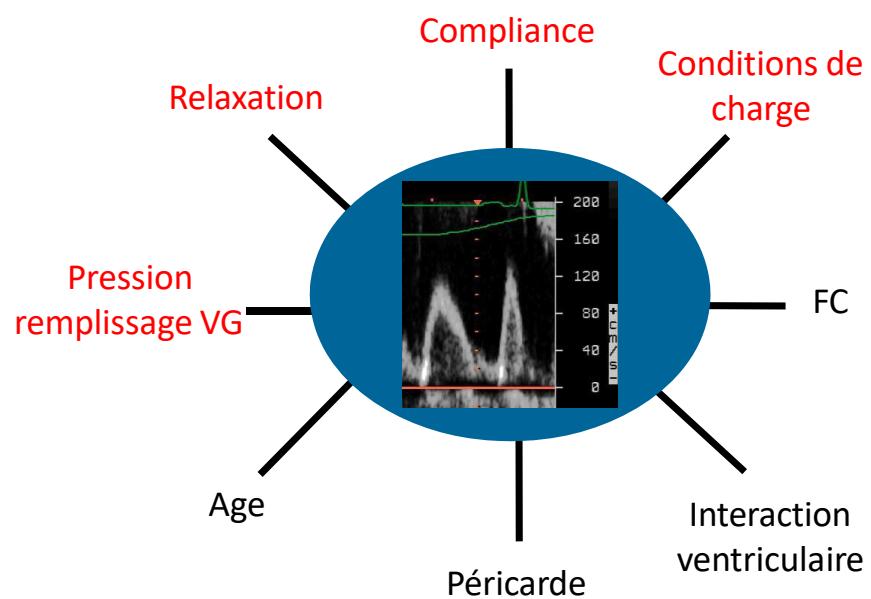
Tissue Doppler imaging (mitral ring)



M-mode color Doppler



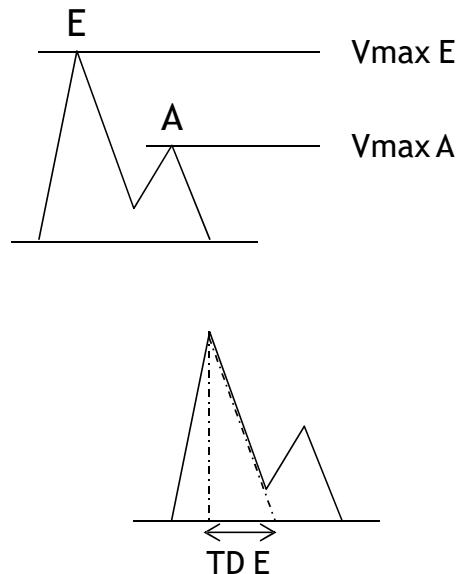
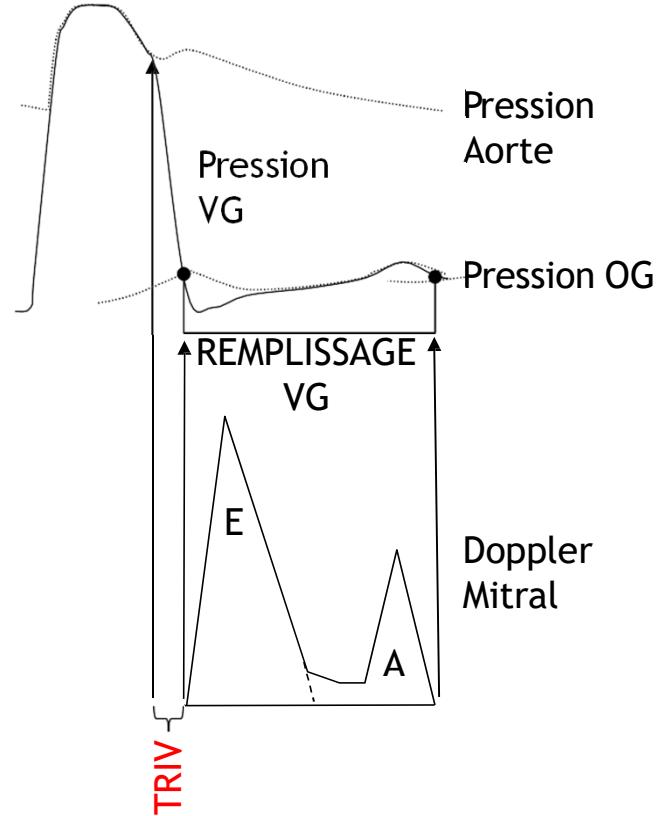
Vignon P et al. In: Hemodynamic monitoring in critically ill patients ; Springer (2008)



ITV E : gradient de pression OG-VG pendant le remplissage ventriculaire précoce : **RELAXATION**

ITV A : gradient de pression OG-VG pendant la contraction auriculaire : **COMPLIANCE**

E / A : contribution relative du remplissage VG précoce et par contraction de l'OG (en l'absence de valvulopathie mitrale)

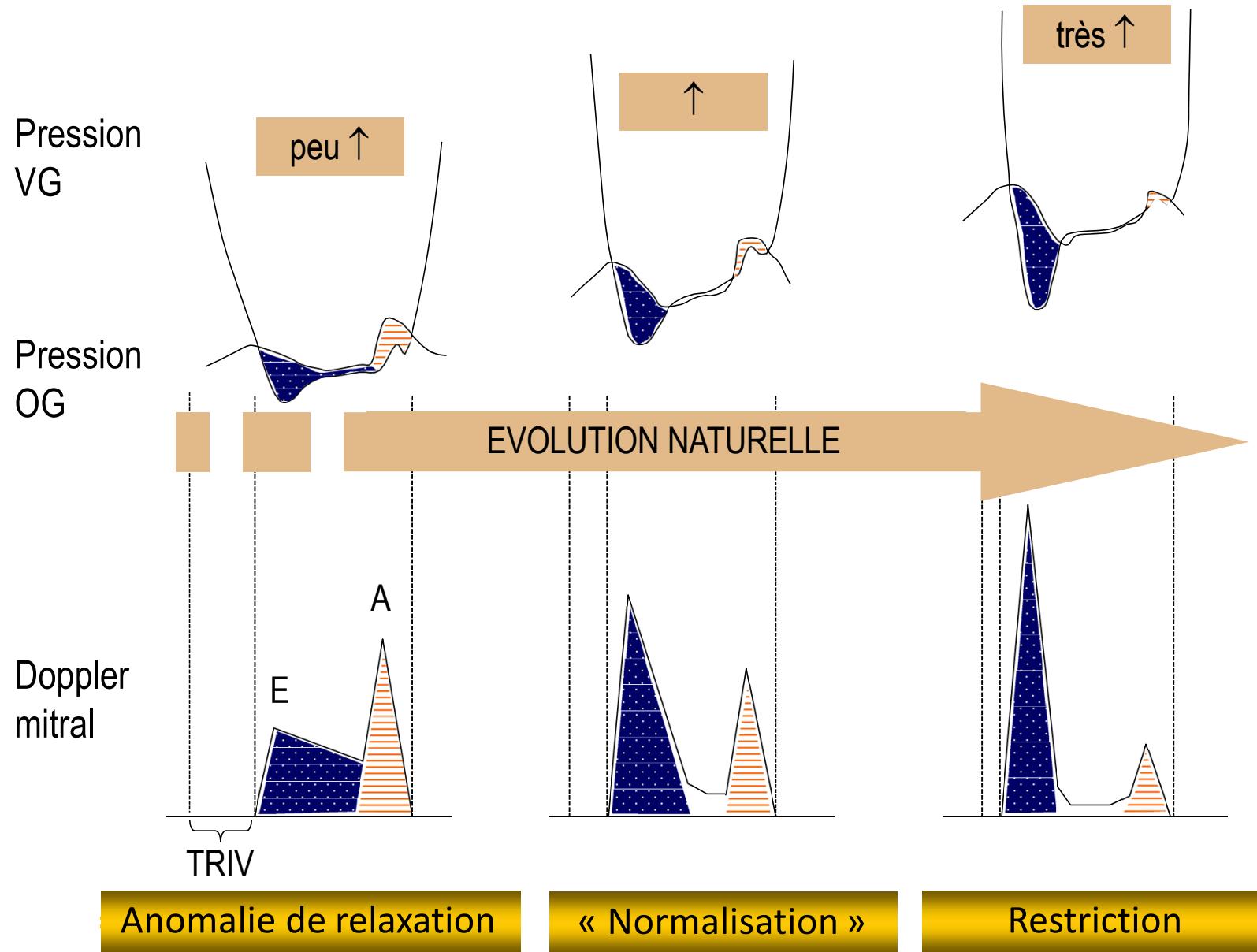


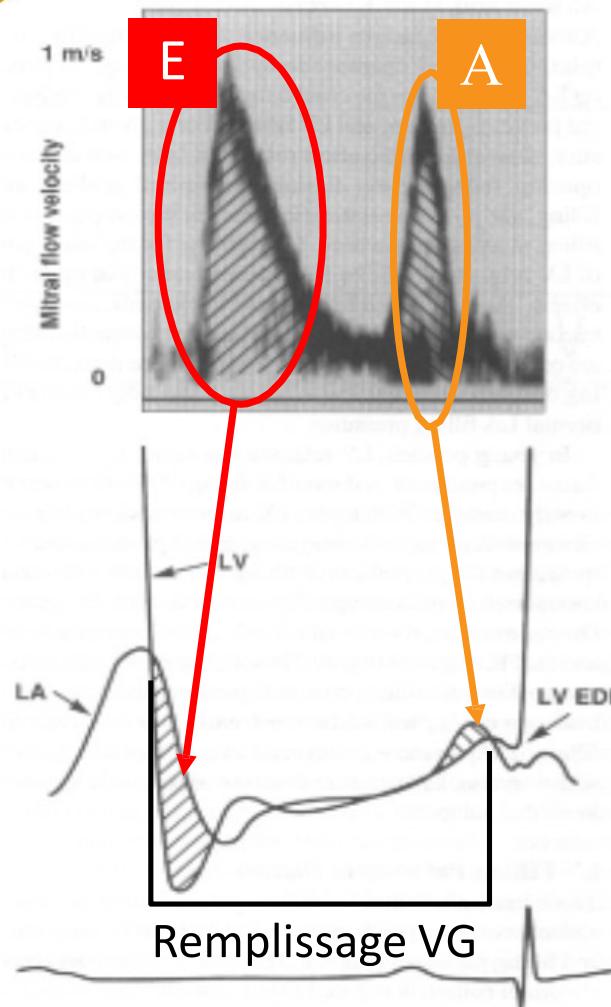
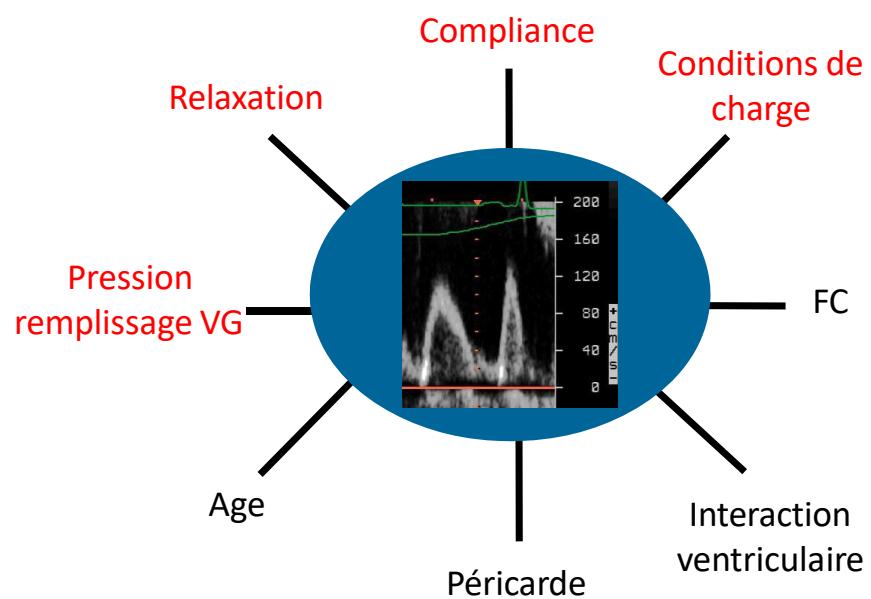
Paramètres simples et reproductibles :

- $V_{max\ E}/ V_{max\ A}$
- Temps de décélération (TD) onde E

Vignon P et al. In: Hemodynamic monitoring in critically ill patients ; Springer (2008)

- ❖ Le temps de relaxation isovolumique (TRIV) reflète au mieux la relaxation
- ❖ Il est difficile à mesurer en ETT et non validé en ETO





ITV E : gradient de pression OG-VG pendant le remplissage ventriculaire précoce : **RELAXATION**

ITV A : gradient de pression OG-VG pendant la contraction auriculaire : **COMPLIANCE**

E / A : contribution relative du remplissage VG précoce et par contraction de l'OG (en l'absence de valvulopathie mitrale)



## Advances in Cardiovascular Imaging

### Established and Novel Clinical Applications of Diastolic Function Assessment by Echocardiography

Jae K. Oh, MD; Sung-Ji Park, MD; Sherif F. Nagueh, MD

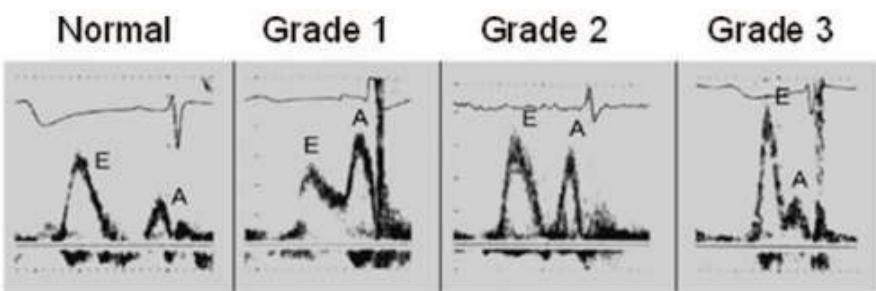
JACC Vol. 32, No. 4  
October 1998:865-75

865

REVIEW ARTICLE

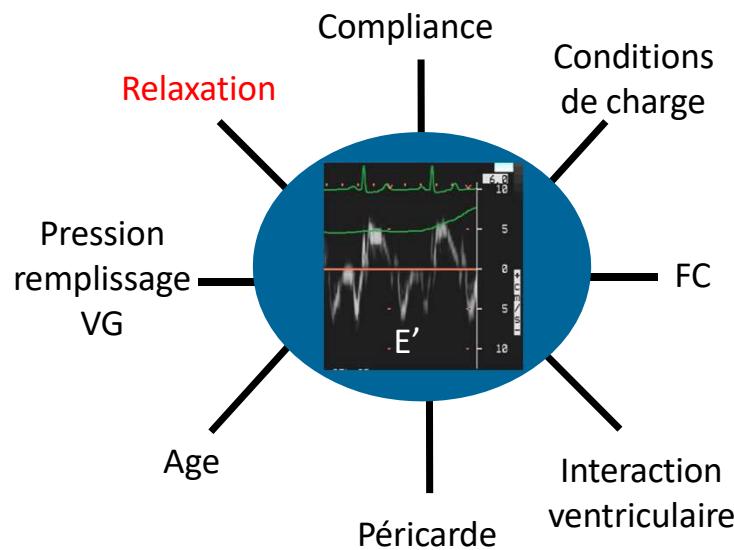
### New Doppler Echocardiographic Applications for the Study of Diastolic Function

MARIO J. GARCIA, MD, FACC, JAMES D. THOMAS, MD, FACC, ALLAN L. KLEIN, MD, FACC  
*Cleveland, Ohio*

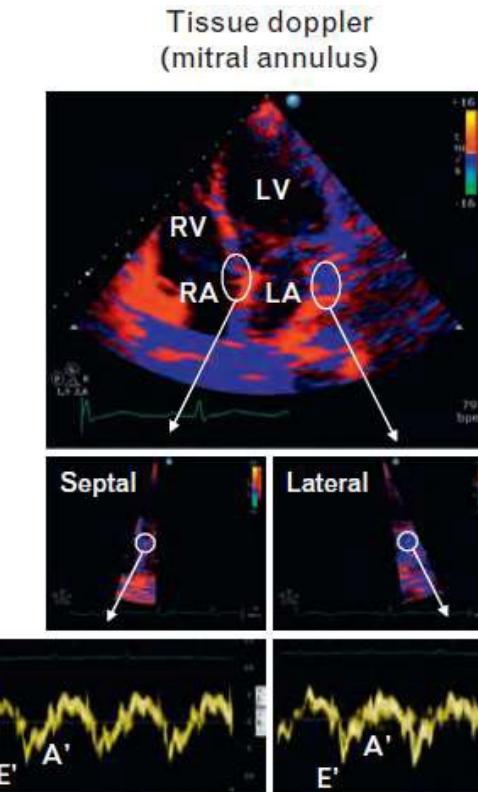


**Table 1.** Stages of Diastolic Dysfunction (see text for details)

	Normal (young)	Normal (adult)	Delayed Relaxation	Pseudonormal Filling	Restrictive Filling
E/A (cm/s)	>1	>1	<1	1-2	>2
DT (ms)	<220	<220	>220	150-200	<150
IVRT (ms)	<100	<100	>100	60-100	<60
S/D	<1	≥1	≥1	<1	<1
AR (cm/s)	<35	<35	<35	≥35*	≥25*
V <sub>p</sub> (cm/s)	>55	>45	<45	<45	<45
E <sub>m</sub> (cm/s)	>10	>8	<8	<8	<8



- ❖ E' est moins précharge-dépendant que les paramètres Doppler conventionnels
- ❖ Protodiastolique, il reflète mieux la relaxation VG

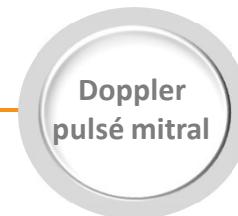


## VALEURS NORMALES

- E' latéral  $\geq 10$  cm/s
- E' septal  $\geq 7$  cm/s

E' non valide si :

- ❖ Valvulopathie mitrale
- ❖ Valve / anneau prothétique
- ❖ BBG, électro-entrainé
- ❖ Péricardite constrictive



## Reproductibilité des mesures

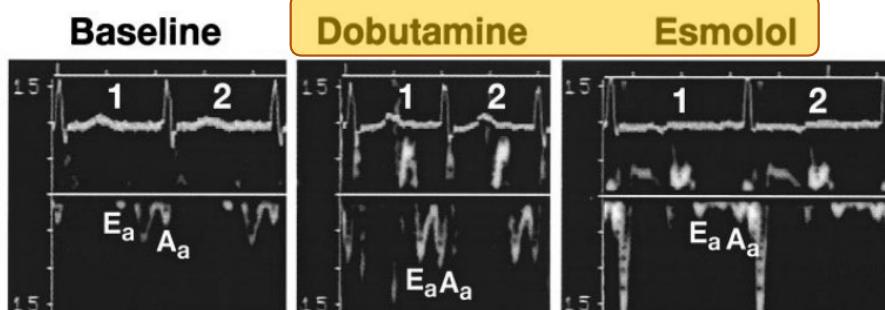
Reproductibilité	TRIV	$V_{max}$ E	$V_{max}$ A	$DT_E$	$V_{max}$ S	$V_{max}$ D	$V_{max}$ E' septal	$V_{max}$ E' lateral	$V_p$
Inter-observateur	10%	1%	3%	13%	4%	5%	4%	5%	11%
Intra-observateur	6%	2%	2%	7%	4%	6%	2%	2%	7%

- ❖ DTI : E' aisée à obtenir même si imagerie 2D suboptimale
- ❖ TM couleur ( $V_p$ ) : nécessite une bonne qualité d'image 2D et l'absence de déformation VG (courant entrant excentré et TM mal aligné)
- ❖  $V_p$  : à éviter en réanimation car difficile à mesurer et peu reproductible.

## Hemodynamic Determinants of the Mitral Annulus Diastolic Velocities by Tissue Doppler

Sherif F. Nagueh, MD, FACC, Huabin Sun, MD, Helen A. Kopelen, RDMS,  
Katherine J. Middleton, RCT, Dirar S. Khoury, PhD

Houston, Texas



E' peut varier sous traitement inotrope (lusinotrope) et après variations aiguës des conditions de charge du VG.

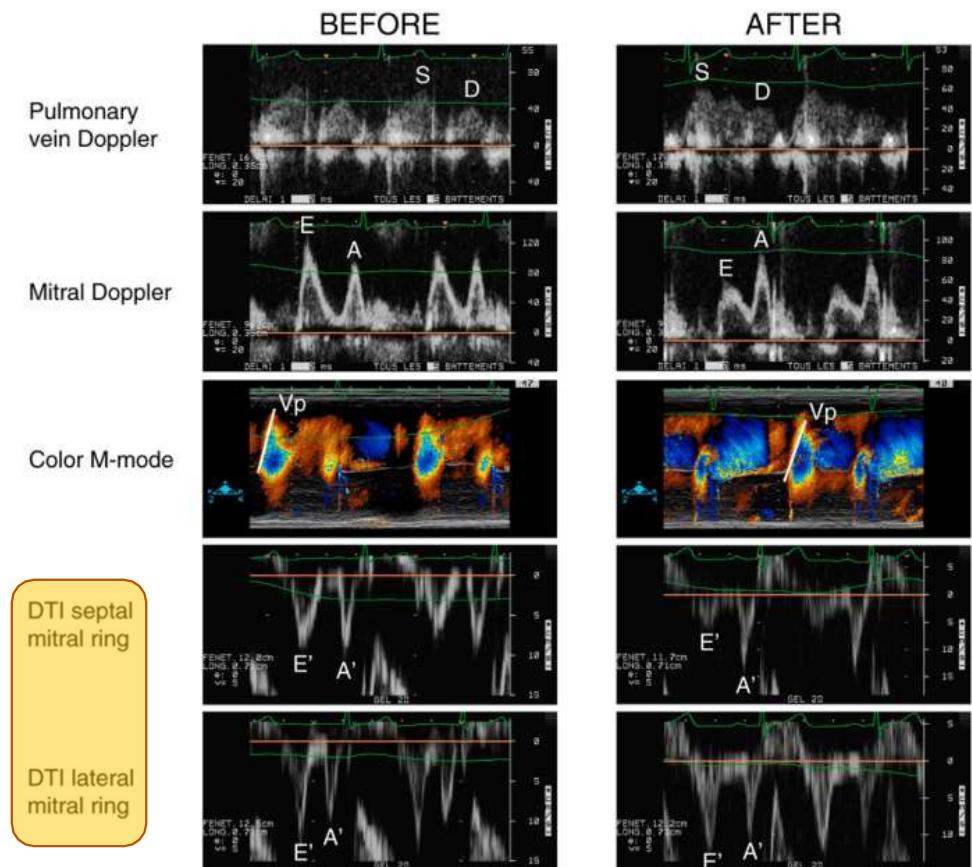
## Research

## Open Access

### Diagnosis of left ventricular diastolic dysfunction in the setting of acute changes in loading conditions

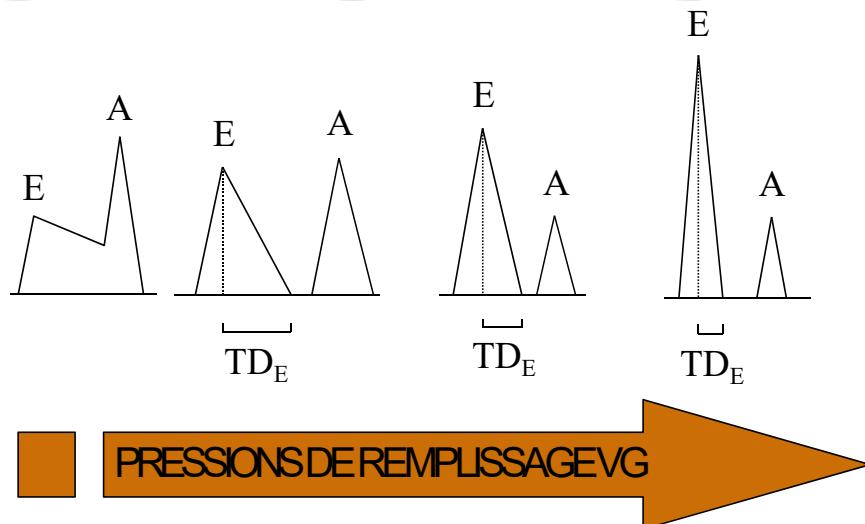
Philippe Vignon<sup>1,2,3</sup>, Vincent Allot<sup>4</sup>, Jérôme Lesage<sup>1</sup>, Jean-François Martaillé<sup>1</sup>, Jean-Claude Aldigier<sup>3,4</sup>, Bruno François<sup>1,2</sup> and Hervé Gastinne<sup>1,3</sup>

Critical Care 2007, 11:R43



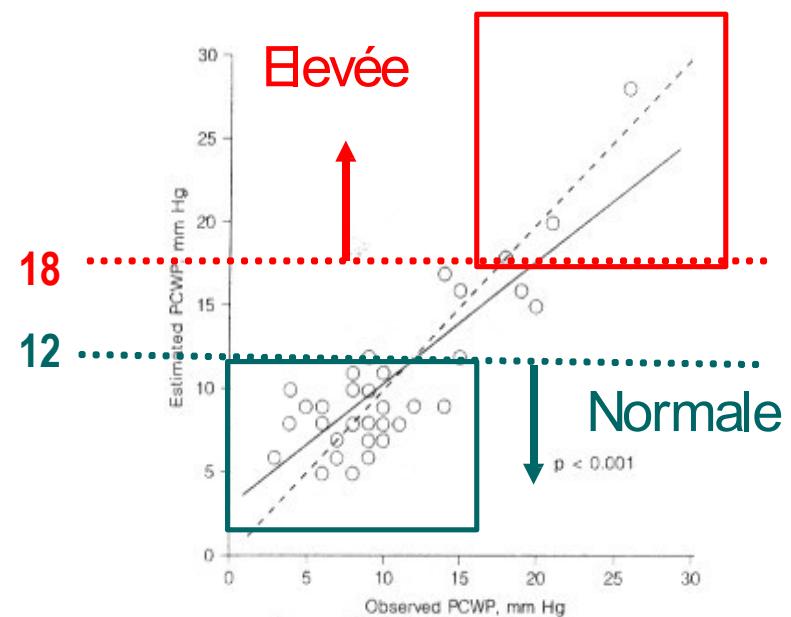
DTI septal  
mitral ring

DTI lateral  
mitral ring



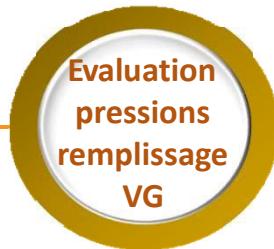
Cœur normal (âge)	Basses	Normales	Normales ou élevées (âge)
Cardiopathie avec dysfonction diastolique VG	Normales ou élevées	Elevées	Très élevées

Le Doppler mitral est performant pour estimer la PAPO lorsqu'elle est élevée



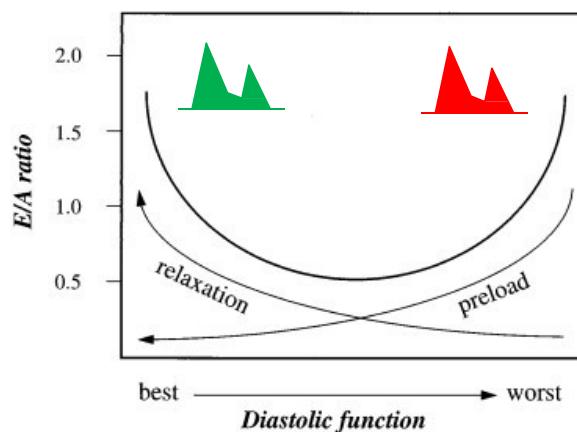
Suwa et al. Am J Noninvas Cardiol 1994 ; 8 : 207-14

	Valeurs seuil	PAPO prédite
E/A	>2	> 18 mmHg
TD <sub>E</sub>	< 120 ms	> 18 mmHg



Bonne relaxation  
Pressions de remplissage basse  
Profil normal

Anomalie de relaxation  
Pressions de remplissage élevées  
Profil normalisé

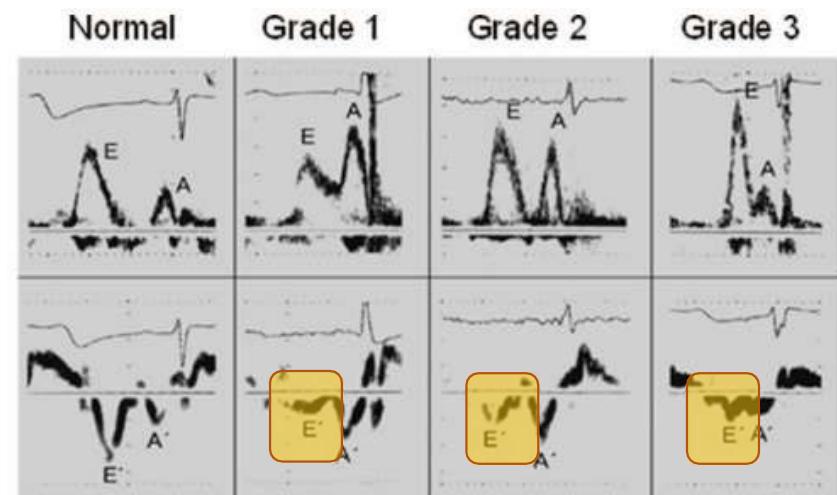


Garcia MJ et al. JACC 1998 ; 32 : 865-75

### Advances in Cardiovascular Imaging

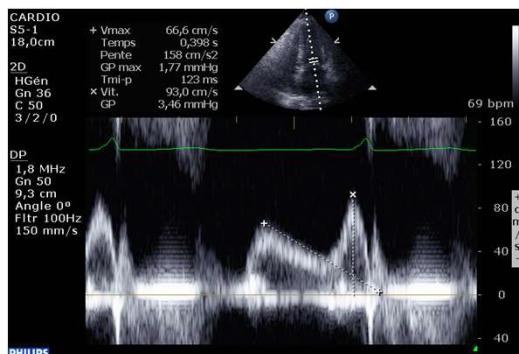
#### Established and Novel Clinical Applications of Diastolic Function Assessment by Echocardiography

Jae K. Oh, MD; Sung-Ji Park, MD; Sherif F. Nagueh, MD

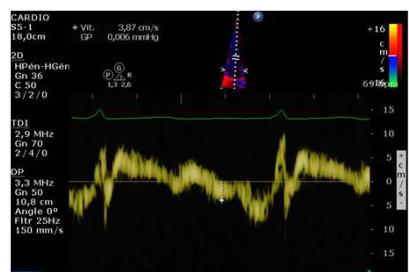


Circ Cardiovasc Imaging 2011 ; 4 : 444-455

Le Doppler mitral est moins performant pour estimer la PAPO en cas de cardiopathie associée : il faut alors lui associer le Doppler tissulaire

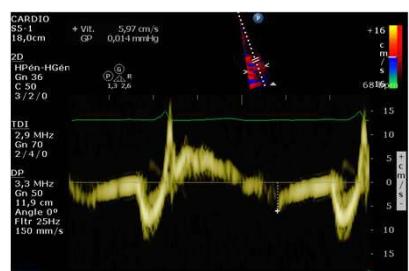


E/A = 0,7 et TDE = 400 ms  
(Grade 1)

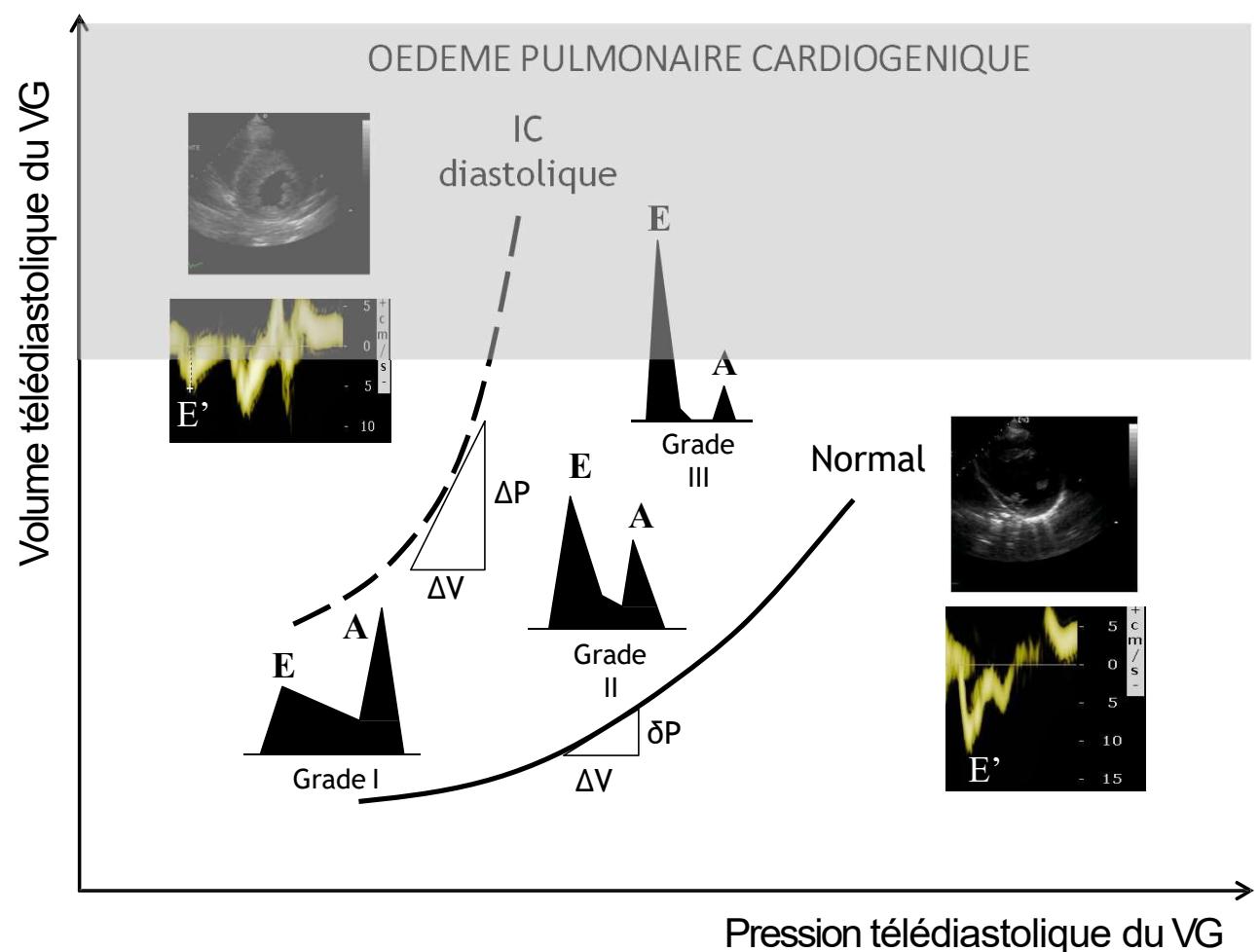


E' septal = 4 cm/s

E/E' moyen : 14



E' lateral = 6 cm/s

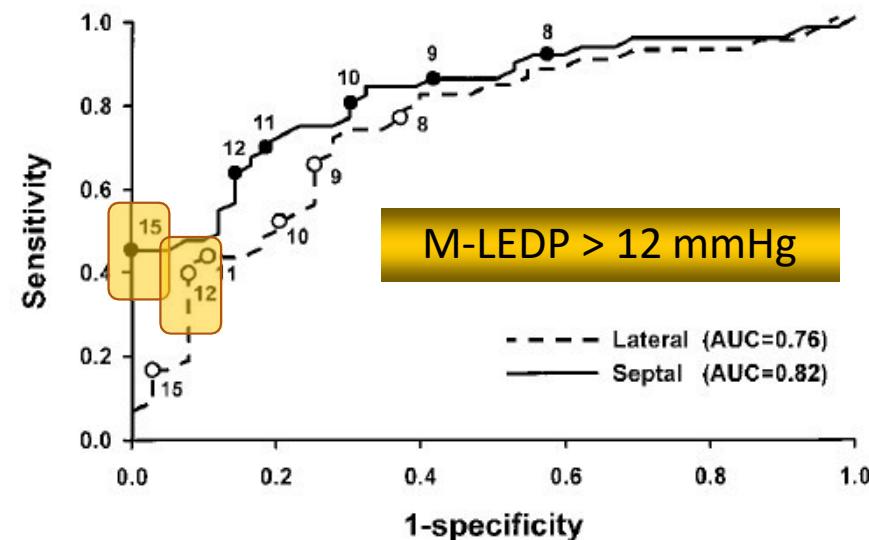




## Cardiopathes en VS

Clinical Utility of Doppler Echocardiography and Tissue Doppler Imaging in the Estimation of Left Ventricular Filling Pressures  
A Comparative Simultaneous Doppler-Catheterization Study

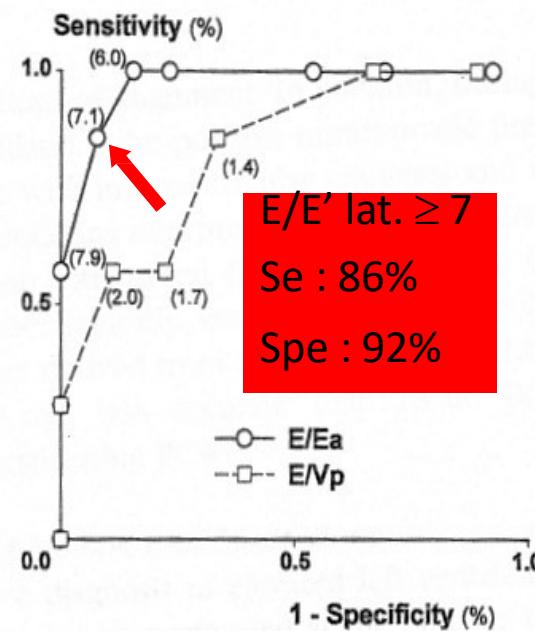
S.R. Ommen, MD; R.A. Nishimura, MD; C.P. Appleton, MD; F.A. Miller, MD; J.K. Oh, MD;  
M.M. Redfield, MD; A.J. Tajik, MD



Circulation 2000 ; 102 : 1788-94

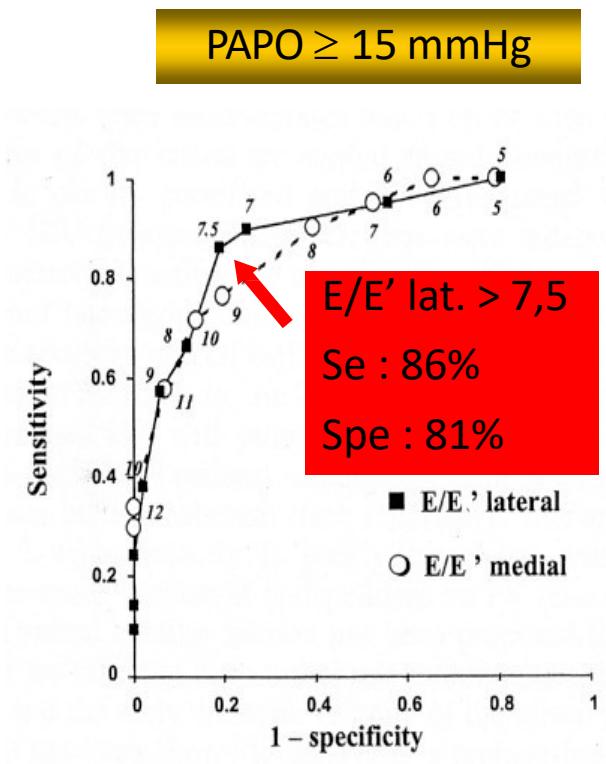
## Patients de réanimation en VAC

PAPO  $\geq$  13 mmHg



Bouhemad et al. Anesthesiology 2003 ; 98: 1091-100

PAPO  $\geq$  15 mmHg



Combes et al. Intensive Care Med 2004 ; 30 : 75-81



Research

Open Access

## Echocardiographic assessment of pulmonary artery occlusion pressure in ventilated patients: a transoesophageal study

Philippe Vignon<sup>1,2,3</sup>, Ali Aithssain<sup>4</sup>, Bruno François<sup>1,2</sup>, Pierre-Marie Preux<sup>3,5</sup>, Nicolas Pichon<sup>1,2</sup>, Marc Clavel<sup>1,2</sup>, Jean-Pierre Frat<sup>6</sup> and Hervé Gastinne<sup>1,3</sup>

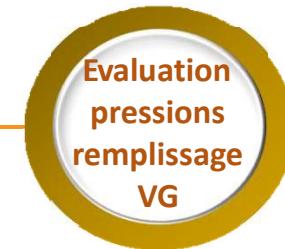
Crit Care 2008 ; 12 : R18

E/E' lateral < 8,0 : PAPO< 18 mmHg

- ❖ Sensibilité : 83 %
- ❖ Spécificité : 88 %

Doppler indices based on DTI of the lateral mitral ring and colour M-mode propagation velocity obtained in protocol B, according to the level of invasive PAOP measured during RHC

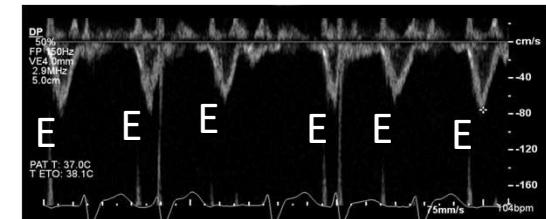
	PAOP ≤ 18 mmHg (n = 24)	PAOP > 18 mmHg (n = 8)	p Value	Dysfonction systolique VG : n = 7
Vp (cm/s)	45 ± 10	35 ± 8	0.05	
E' lateral (cm/s)	12.9 ± 3.9	9.2 ± 1.3	0.01	
E/Vp	1.7 ± 0.6	2.7 ± 0.5	0.0006	
E/E' lateral	5.9 ± 2.2	10.6 ± 3.3	0.0002	Fonction systolique VG normale : n = 49



## Patients en FA

Paramètres Doppler	Valeur seuil	PAPO prédictive	Sensibilité	Spécificité
$TD_E$	< 150 ms	> 15 mmHg	71%	100%
	< 120 ms	$\geq 20$ mmHg	100%	96%
$E/E'$ septal	$\geq 11$	$\geq 15$ mmHg	75%	93%

Moyenne de 10 cycles cardiaques...  
...ou de 3 battements non consécutifs avec  
une durée de cycle dans les 10 à 20% de  
variation de fréquence cardiaque



### ASE/EACVI GUIDELINES AND STANDARDS

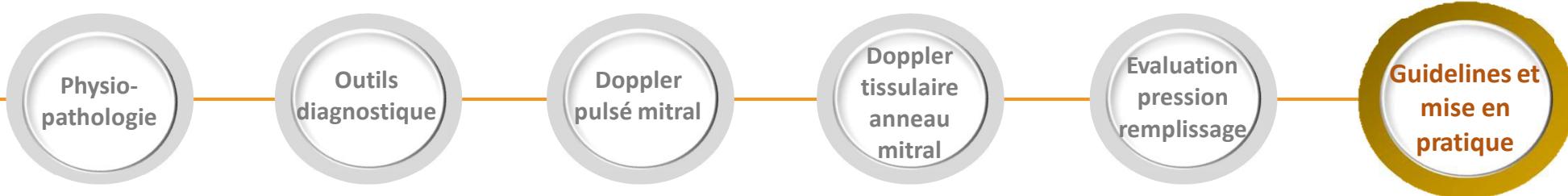
Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography:  
An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

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(J Am Soc Echocardiogr 2016;29:277-314.)

**Table 6** Assessment of LV filling pressures in special populations

Disease	Echocardiographic measurements and cutoff values
AF <sup>43,94-99</sup>	Peak acceleration rate of mitral E velocity ( $\geq 1,900$ cm/sec $^2$ ) IVRT ( $\leq 65$ msec) DT of pulmonary venous diastolic velocity ( $\leq 220$ msec) E/Vp ratio ( $\geq 1.4$ ) <b>Septal E/e' ratio (<math>\geq 11</math>)</b>



## Recommandations internationales : pourquoi ?

### ASE/EACVI GUIDELINES AND STANDARDS

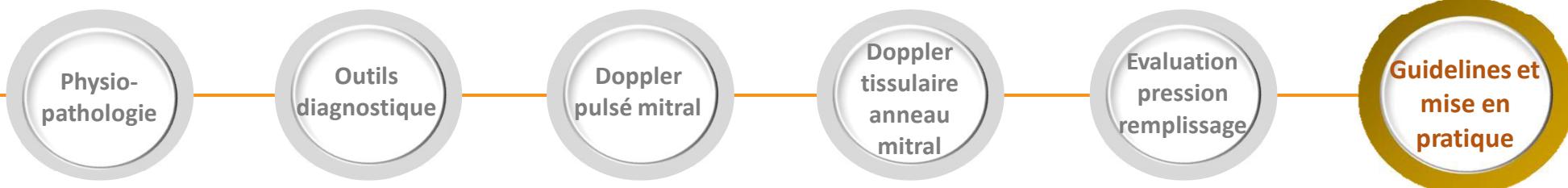
#### Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

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when feasible, particularly in patients referred with symptoms of dyspnea or diagnosis of "heart failure." In addition, the grade of LV diastolic dysfunction should be included in the reports along with the estimated LV filling pressures. The rationale for this recommendation comes from several single center and epidemiologic studies showing the independent and incremental prognostic information provided by LV diastolic dysfunction grade in several settings including HFrEF, HFpEF and acute myocardial infarction.<sup>72-87</sup> Finally, when feasible,

with heart failure. In patients with AF, Doppler assessment of LV diastolic function is limited by the variability in cycle length, the absence of organized atrial activity, and the frequent occurrence of LA enlargement regardless of filling pressures. In general, when



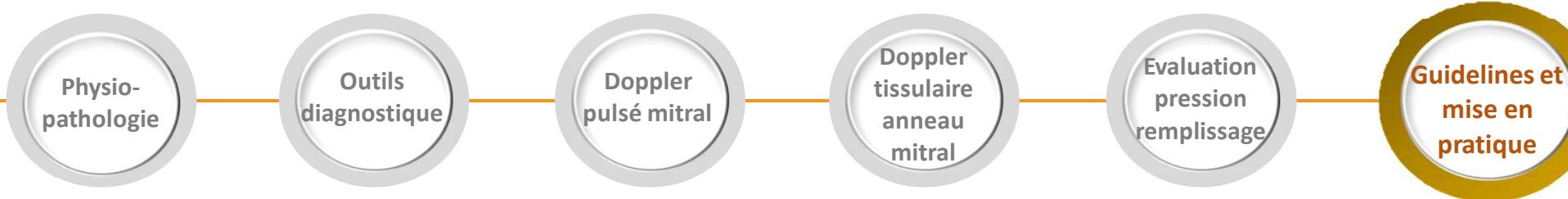
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(J Am Soc Echocardiogr 2016;29:277-314.)

- ❖ Les critères diagnostiques de dysfonction diastolique du VG associent l'anomalie de relaxation ( $E'$  bas), l'augmentation des pressions de remplissage du VG ( $E/E'$  moyen élevé et dilatation de l'OG), et l'HTAP postcapillaire en résultant ( $V_{max}$  IT qualifiante)
- ❖ La dysfonction systolique (FEVG basse) est toujours considérée comme étant associée à une dysfonction diastolique
- ❖ Lorsque la FEVG est normale, la dysfonction diastolique doit être cherchée si dyspnée / IRA
- ❖ Une fois la dysfonction diastolique établie, sa sévérité doit être déterminée (3 grades).



# ASE / EACVI recommendations : 2025 update pour FEVG conservée

## GUIDELINES AND STANDARDS

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography

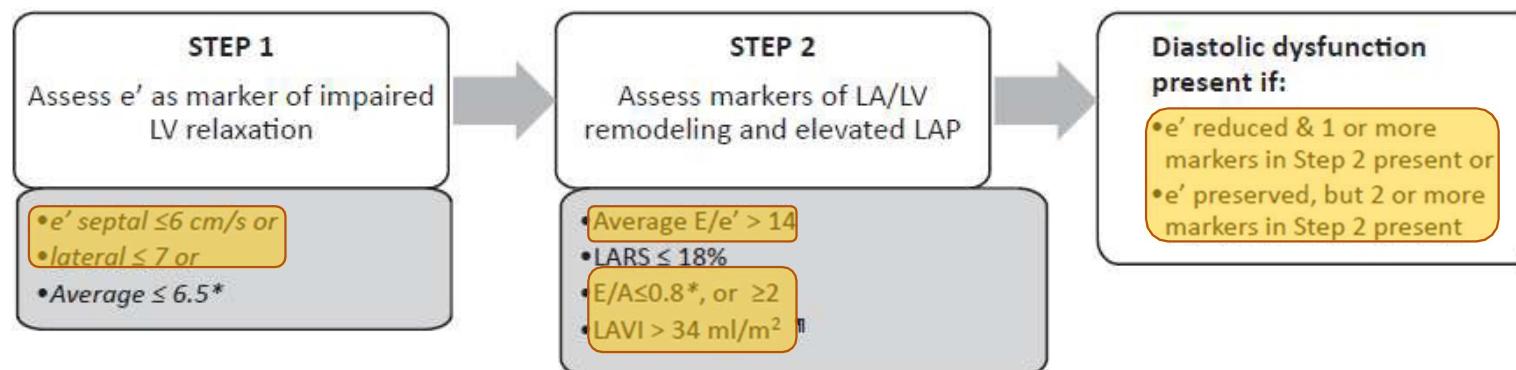


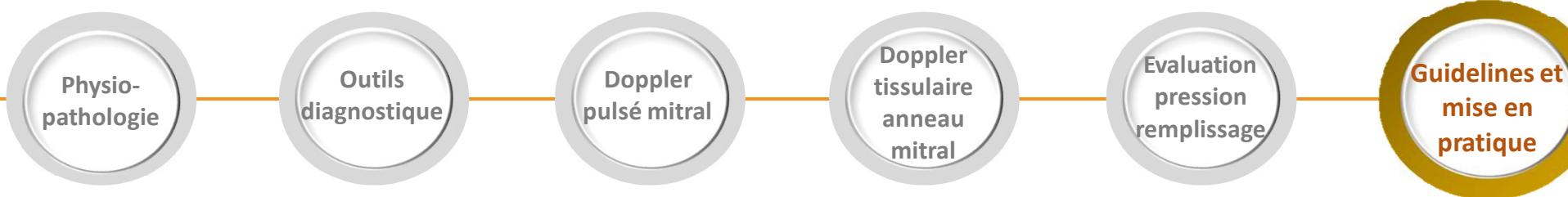
Sherif F. Naguch, MD, FASE (Chair), Damita Y. Sanborn, MD, FASE (Co-Chair), Jac K. Oh, MD, FASE, Bonita Anderson, MAppSc, DMU, ACS, FASE, FASA, Kristen Billck, BS, ACS, RCS, RDMS, FASE, Genevieve Derumeaux, MD, PhD, Allan Klein, MD, FASE, Konstantinos Koulogannis, MD, FASE, Carol Mitchell, PhD, ACS, RDMS, RDMS, RVT, RT(R), FASE, Amil Shah, MD, Kavita Sharma, MD, Otto A. Smiseth, MD, PhD, Honorary FASE, and Teresa S. M. Tsang, MD, FASE, *Houston and Dallas, Texas; Boston, Massachusetts; Rochester, Minnesota; Brisbane, Australia; San Diego, California; Creteil, France; Cleveland, Ohio; Morristown, New Jersey; Madison, Wisconsin; Baltimore, Maryland; Oslo, Norway; and Vancouver, British Columbia, Canada*

(J Am Soc Echocardiogr 2025;38:537-69.)

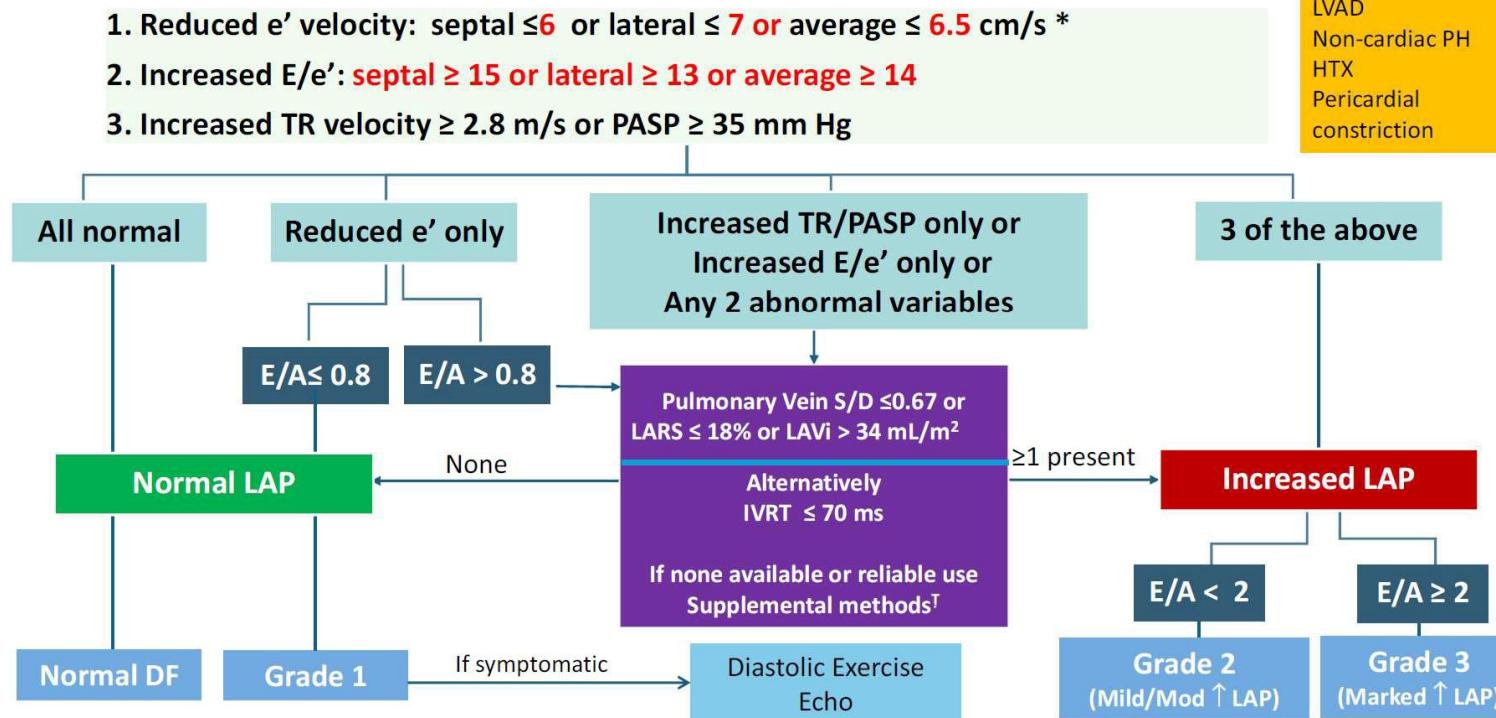
**Table 6** Mitral annular e' velocity values for diagnosis of impaired LV relaxation

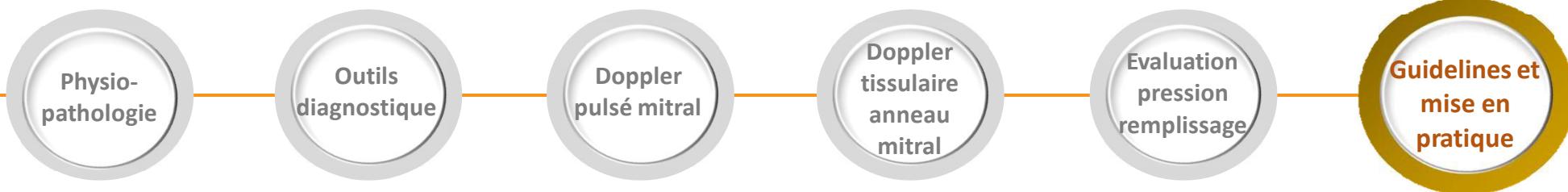
	20-39 y	40-65 y	>65 y
1. Septal e', cm/s	<7	<6	<6
2. Lateral e', cm/s	<10	<8	<7
3. Average e', cm/s	<9	<7	<6.5



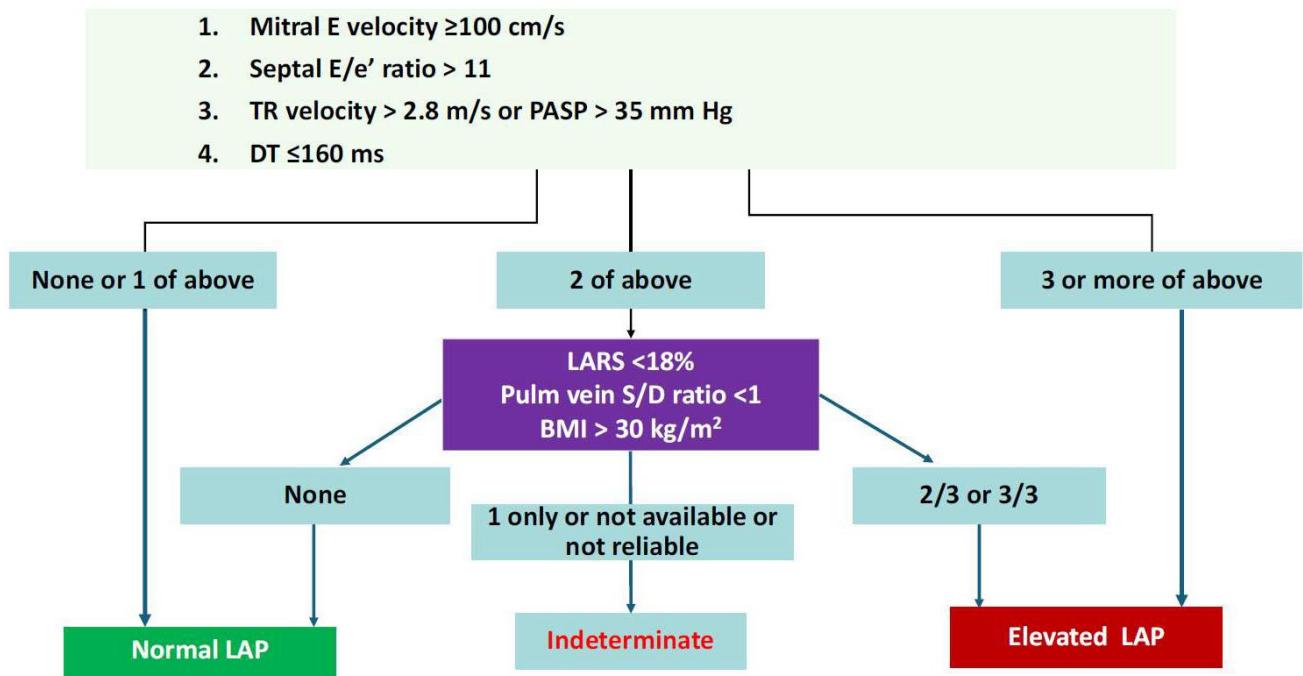
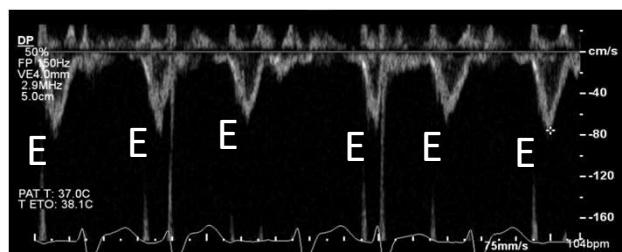


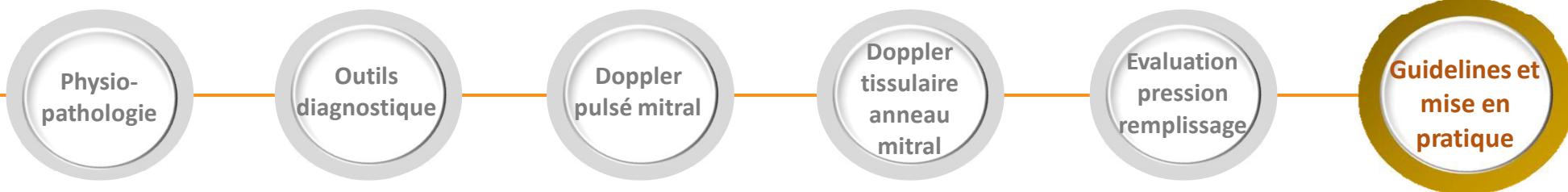
## LV Diastolic Function Grading & LAP Estimation



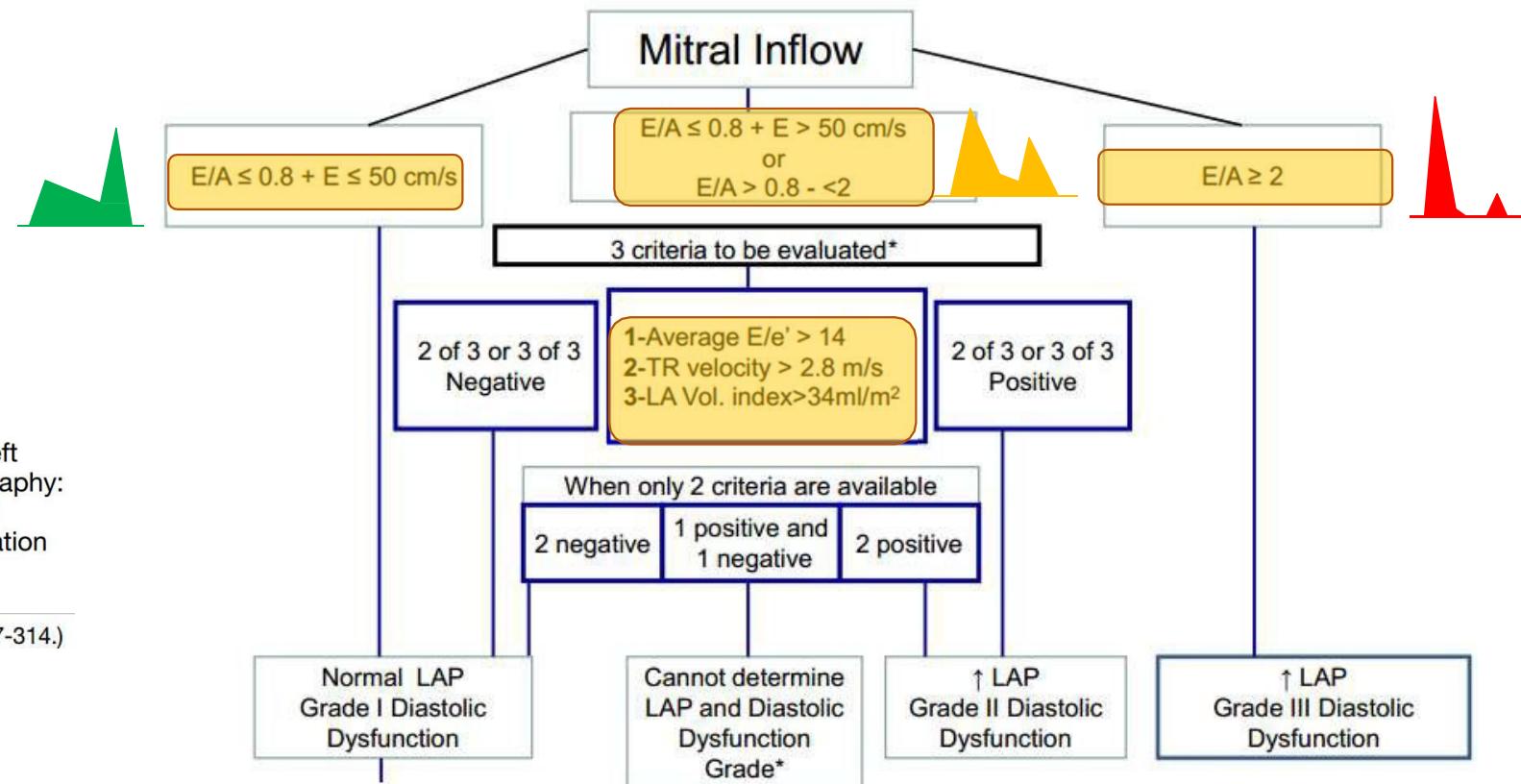


## LAP Estimation in Atrial Fibrillation





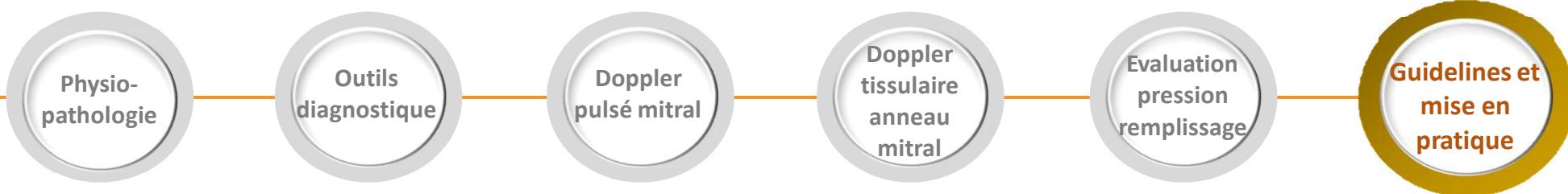
## ASE / EACVI 2016 recommendations : FEVG basse



ASE/EACVI GUIDELINES AND STANDARDS

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## Absence de dysfonction diastolique du VG

REVIEW



### Ventricular diastolic abnormalities in the critically ill

Philippe Vignon<sup>a,b,c</sup>

Vignon P Curr Opin Crit Care 2013 ; 19 : 242-9

Echocardiographic findings allowing to rule out a relevant LV diastolic dysfunction

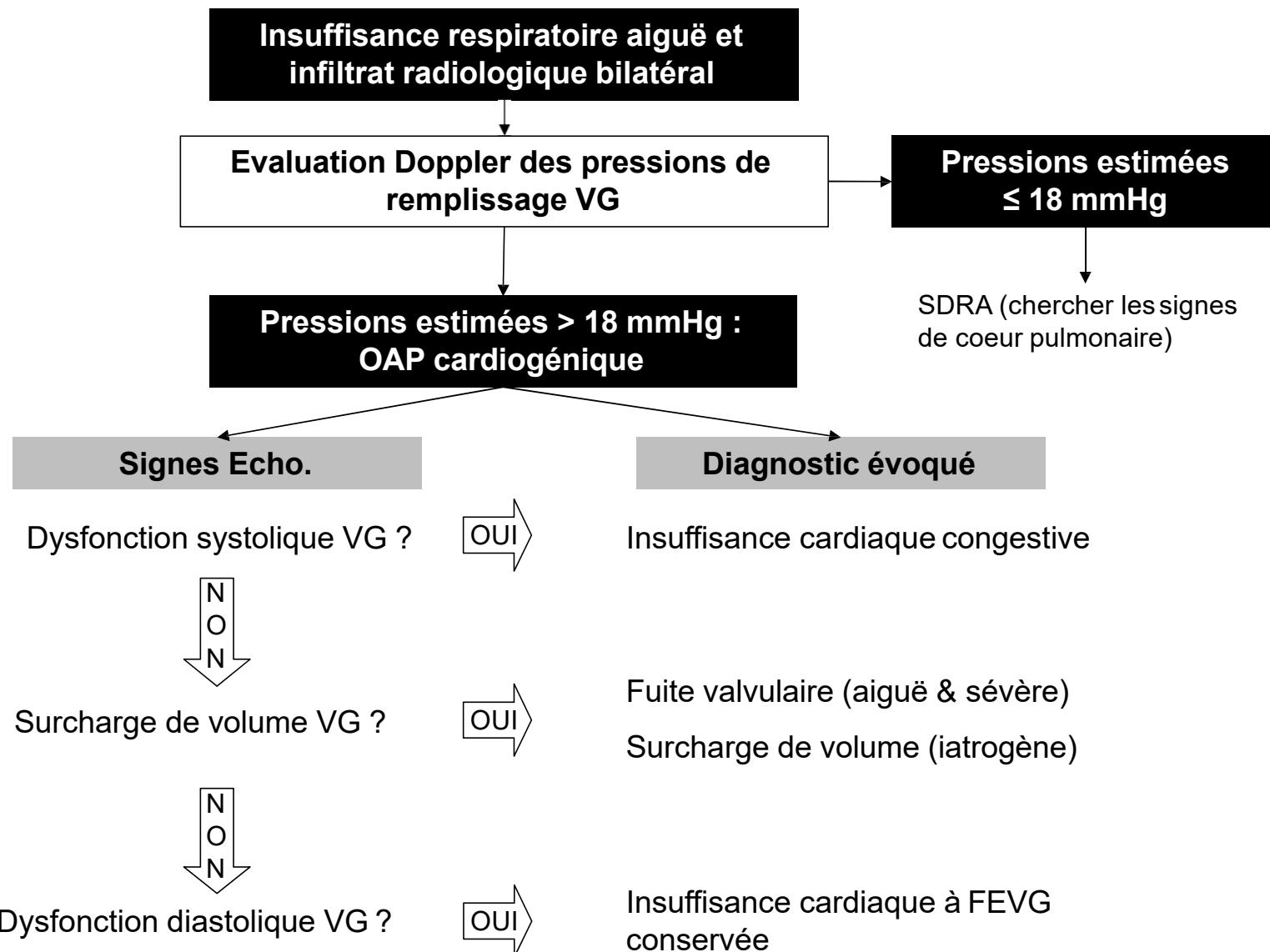
No LV morphological abnormality

Normal left atrial size

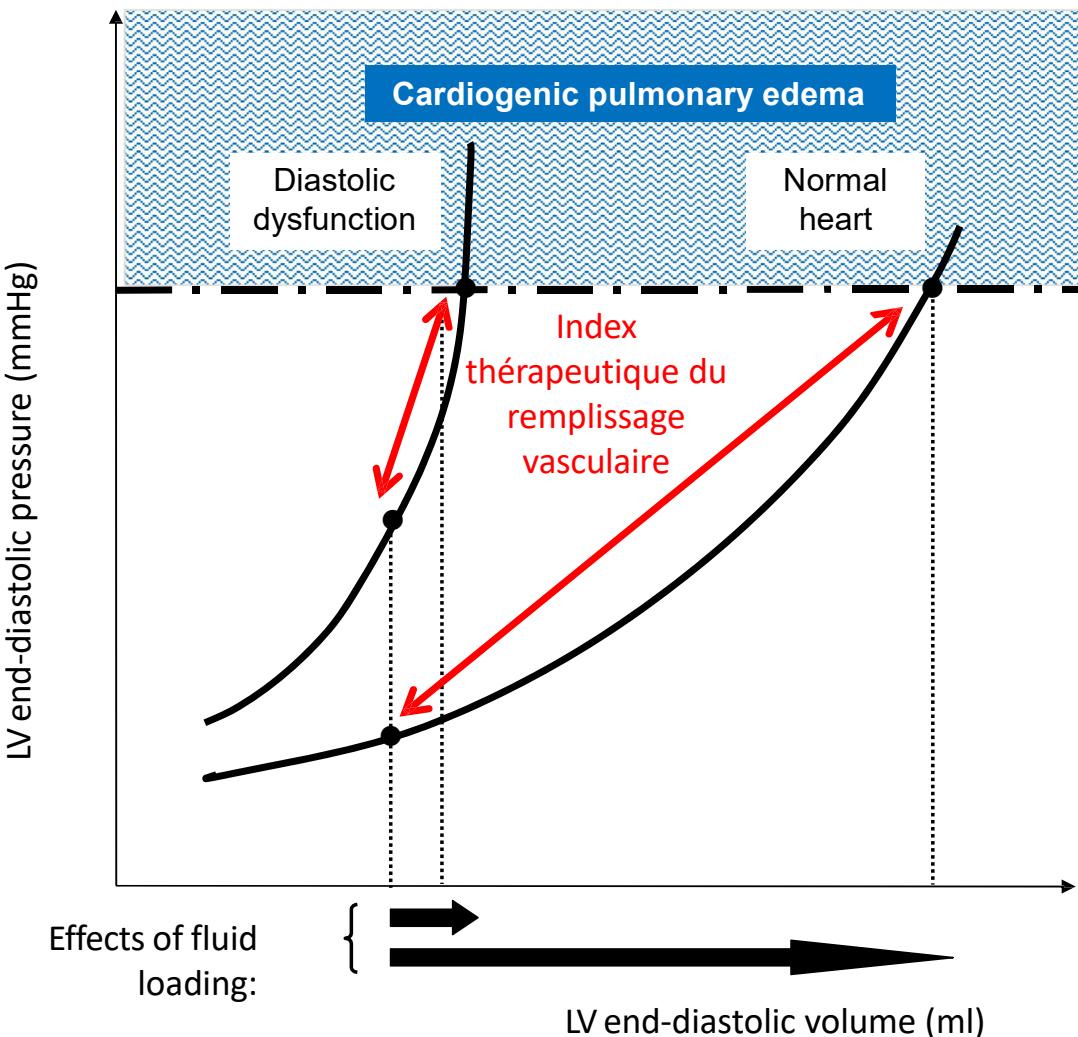
Homogeneous pattern of LV contraction

Normal or abnormal relaxation (grade I) pattern according to age, and no cardiac disease

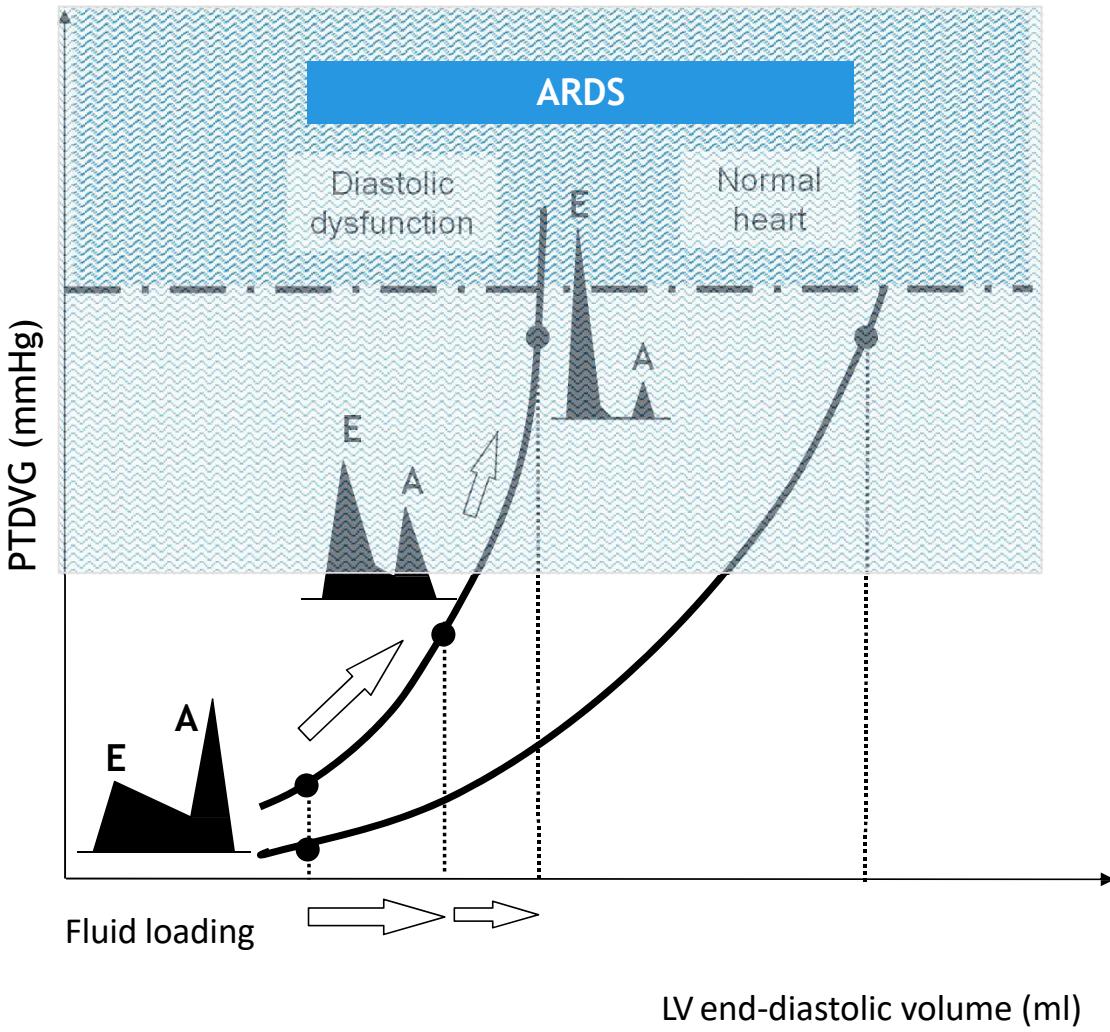
$E/E' < 8$

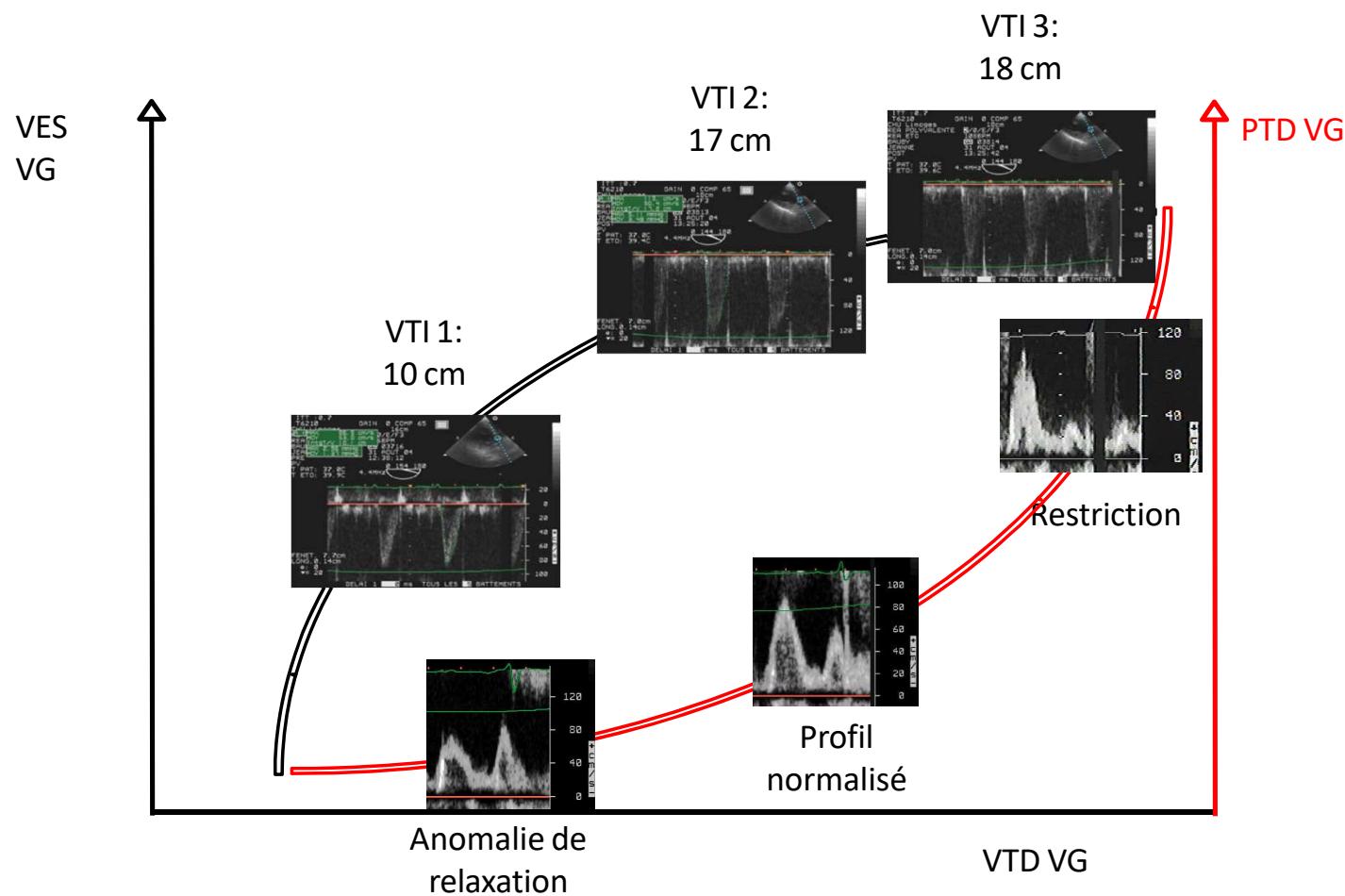
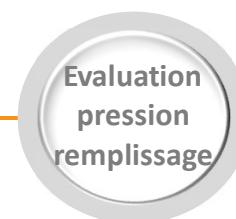
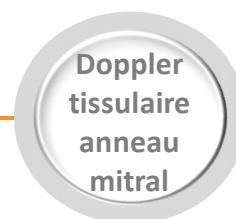


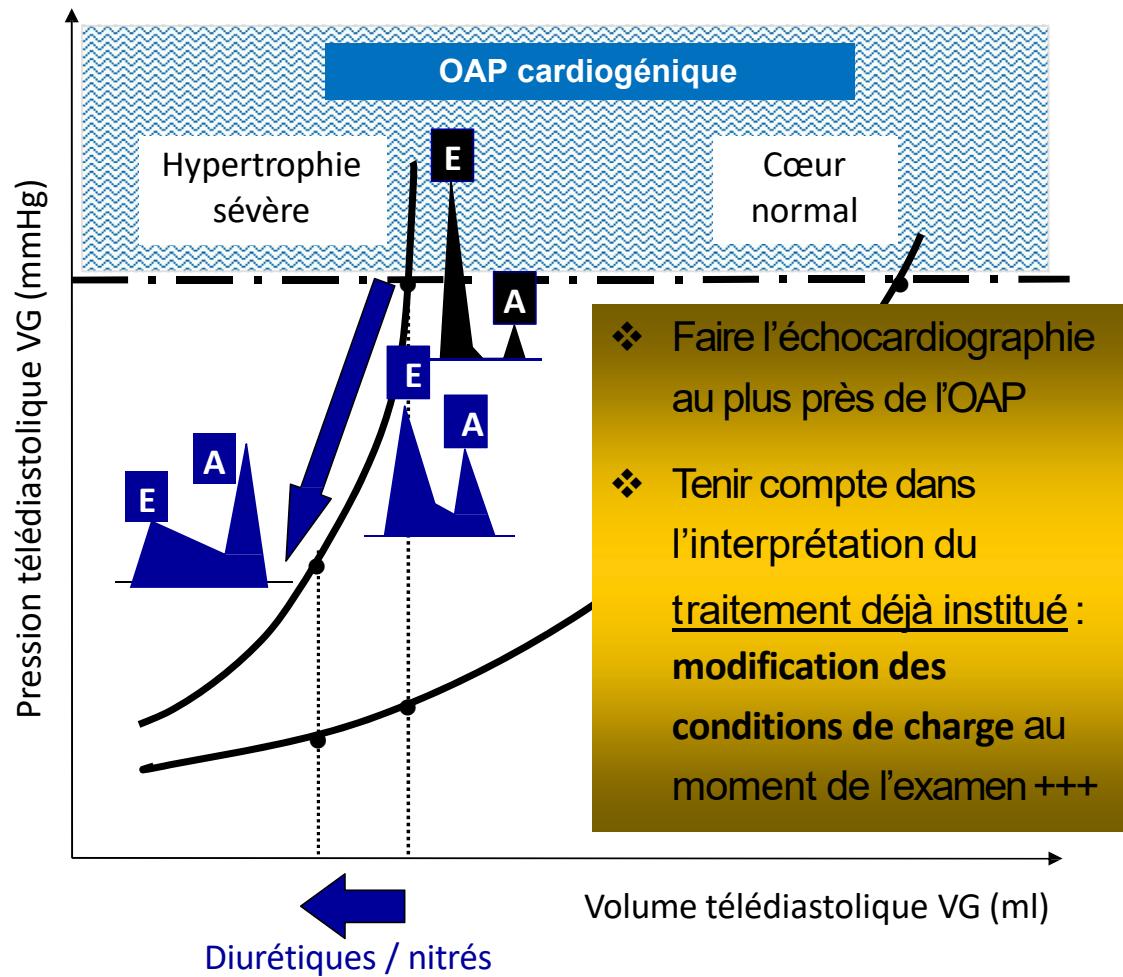
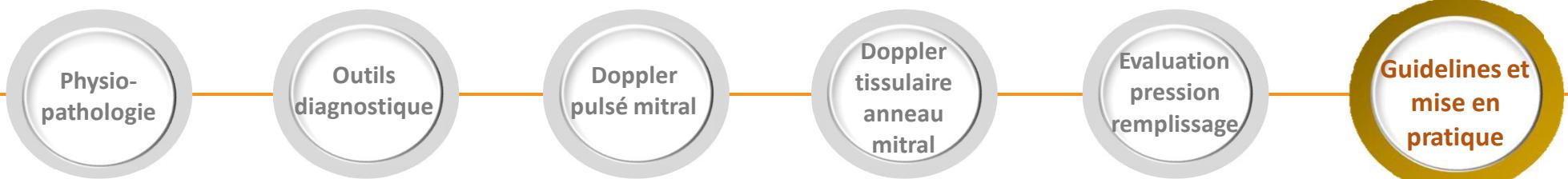
## OAP cardiogénique



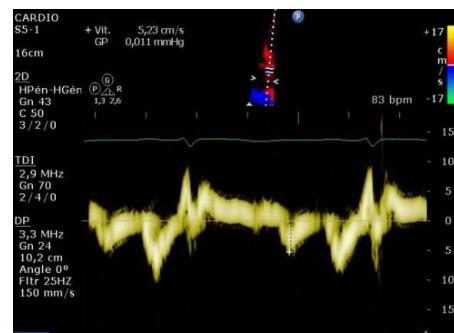
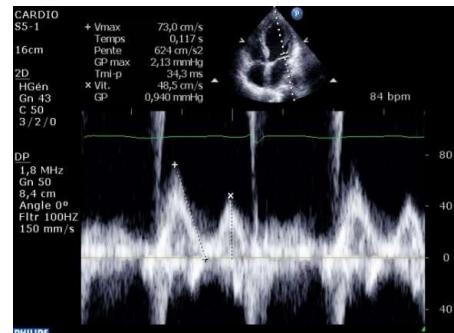
## OAP lésionnel





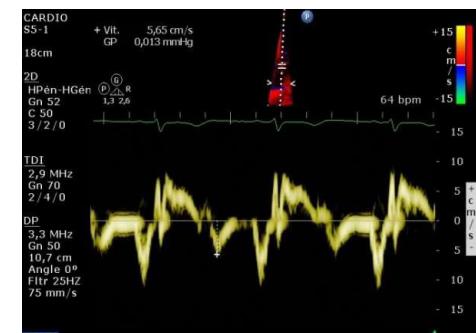
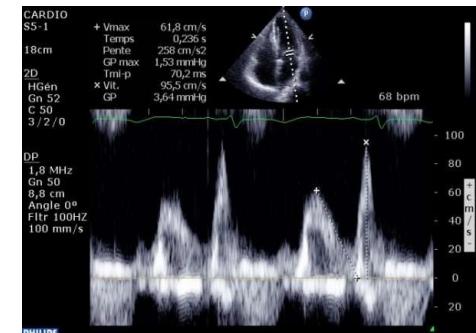


### Admission (pulmonary edema)

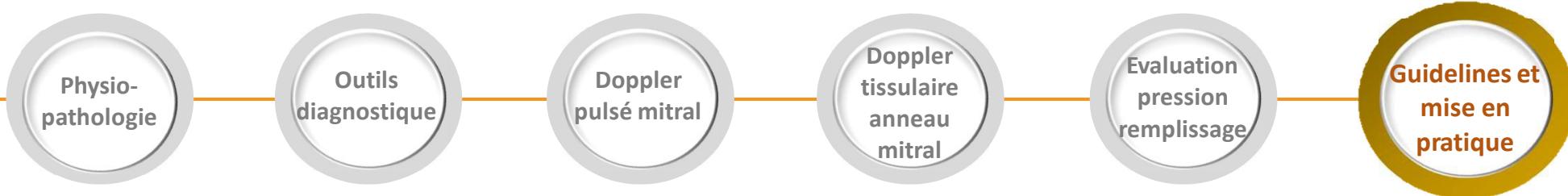


E/E': 14

### After treatment (vasodilators & diuretics)



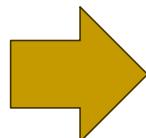
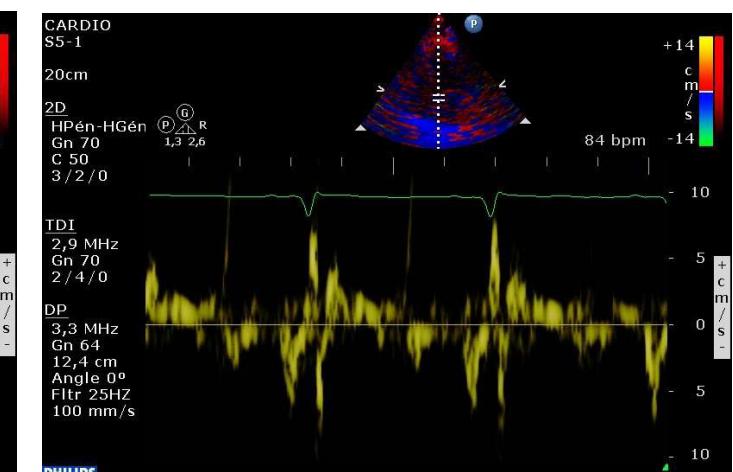
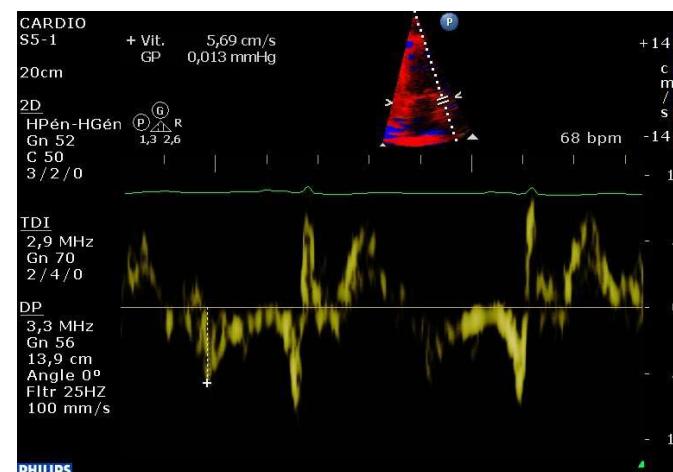
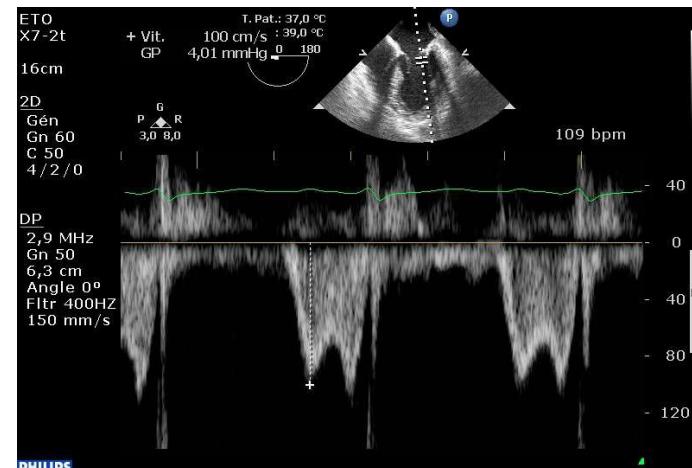
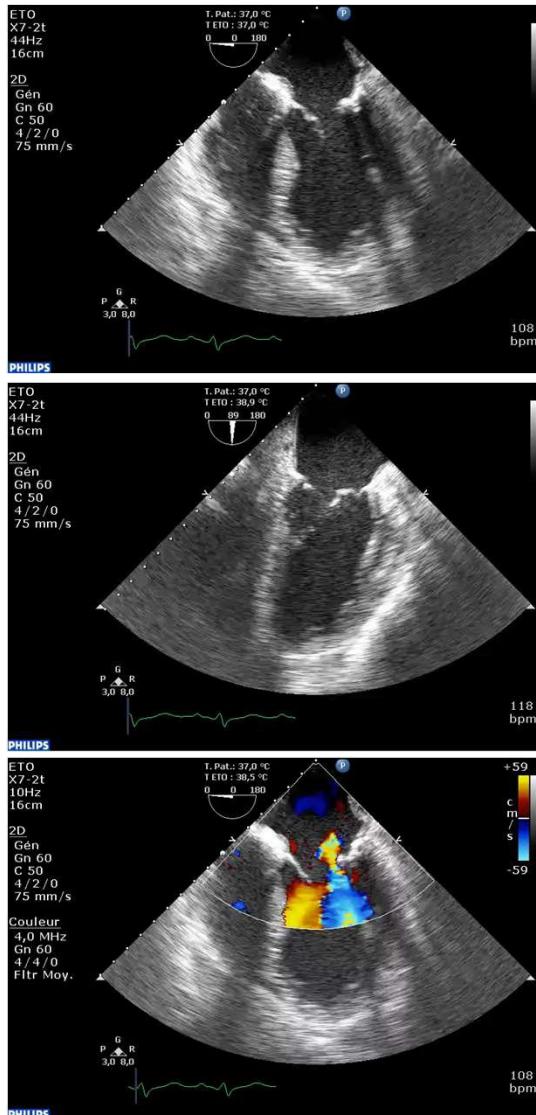
E/E': 11



## Cas Clinique : échec de sevrage du respirateur

- ❖ Homme de 76 ans, hypertendu, cardiomyopathie ischémique avec FEVG à 45%
- ❖ Pontages aorto-coronaire sans CEC (pas de problèmes peropératoires)
- ❖ Transfert pour sevrage difficile après 2 échecs d'épreuve de VS sur tube en T
- ❖ ETT: fonction systolique VG normale (FEVG à 55%), E/E' moyen à 10, IM minime
- ❖ Bilan hydrique négatif (- 6 kgs sous diurétiques) : échec de l'épreuve de VS sur tube à 10 min
- ❖ Patient immédiatement reconnecté au respirateur et ETO en volume contrôlé.

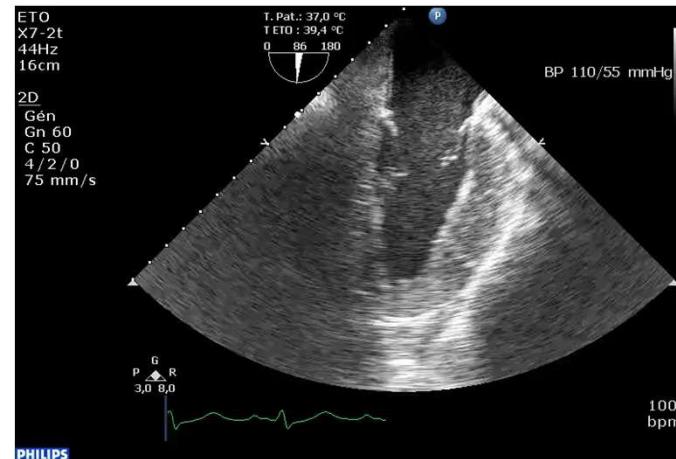
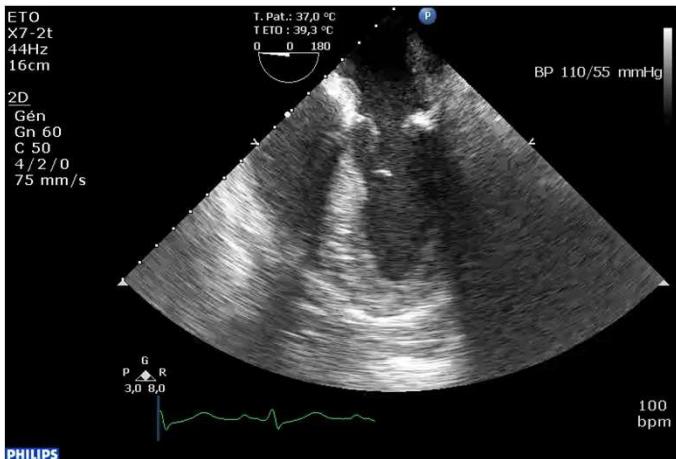
## Echec pièce en T: PA= 210 / 115 mmHg



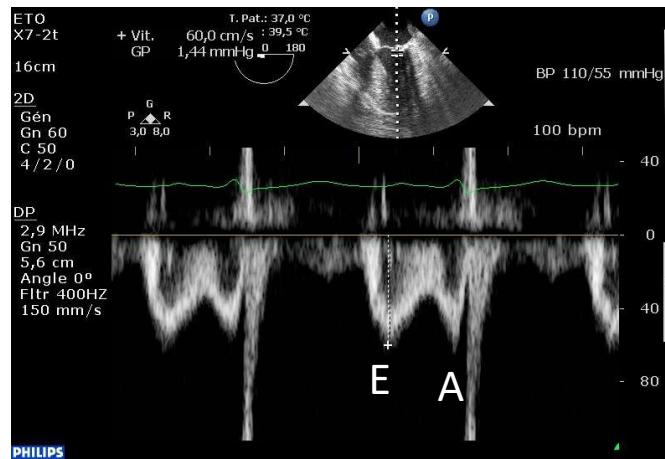
Traitement antihypertenseur IV

Vmax E: 100 cm/s  
E/E' moyenné : 17

## VAC& Nicardipine IV : PA= 110 / 55 mmHg

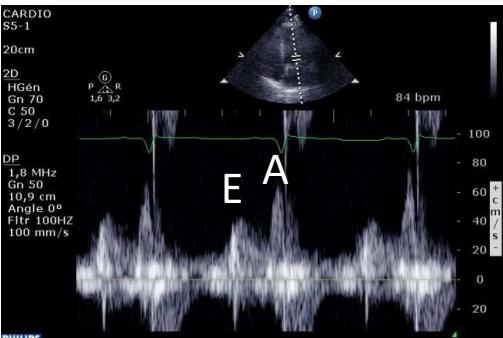


Vmax E: 60 cm/s  
E/E' moyenné : 10

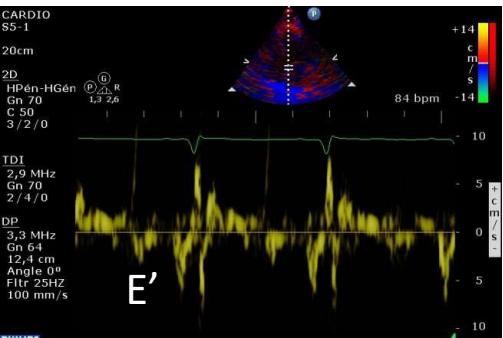
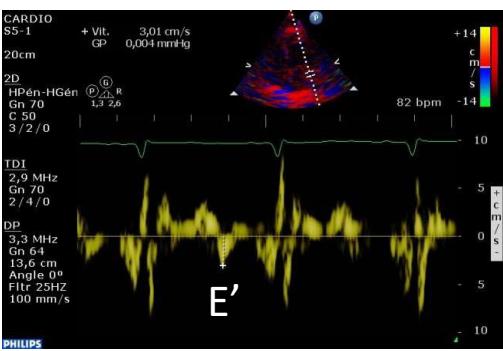


Vmax E: 40 cm/s  
E/E' moyen : 10

Before SBT

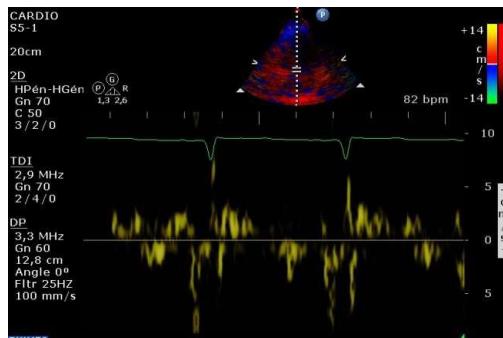
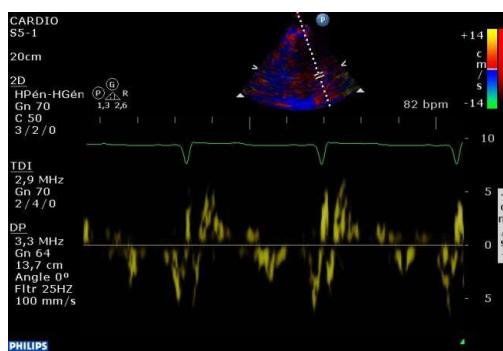
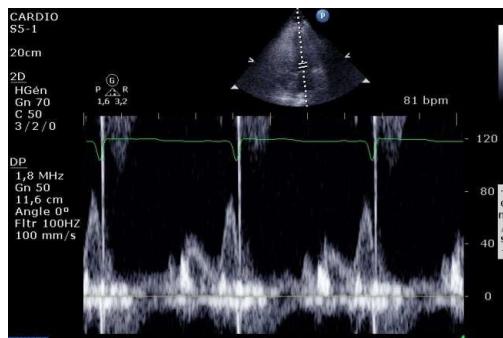


TTT personnalisé



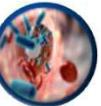
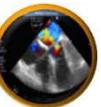
SBT

Vmax E: 40 cm/s  
E/E' moyen : 10



Epreuve de VS+ / extubation

# Fonction diastolique et pression de remplissage du VG



- ❖ Propriétés diastoliques et pressions de remplissage du VG sont étroitement liées
- ❖ En cas de dysfonction diastolique, la fonction systolique peut être conservée ou non
- ❖ Le diagnostic d'**OAP cardiogénique** repose sur la mise en évidence d'une **élévation des pressions de remplissage du VG** à l'instant  $t$ , souvent associée à une dysfonction diastolique (sévère) & cardiopathie
- ❖ Les recommandations internationales ne sont pas adaptées au patient en état critique
- ❖ **L'élévation des pressions de remplissage** est l'information pertinente pour le réanimateur
- ❖ OAP à FEVG conservée : documenter **au plus près de l'épisode** pour éviter les diagnostics par excès.