Intensive Care Med (2005) 32:9–10
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EDITORIAL

Bernard P. Cholley
Antoine Vieillard-Baron
Alexandre Mebazaa

Echocardiography in the ICU: time for widespread use!

Intensive Care Med
DOI 10.1007/s00134-007-0923-5

CLINICAL COMMENTARY

Antoine Vieillard-Baron
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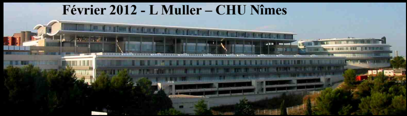
Echocardiography in the intensive care unit: from evolution to revolution?

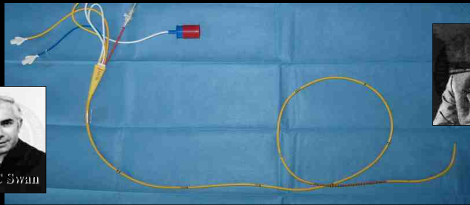
Echographie cardiaque en réanimation.

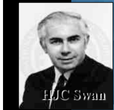
Février 2012 - L Muller – CHU Nîmes



Le moniteur hémodynamique idéal : conception classique

Précharge	Fonction pompe	Post charge	Ox tissulaire
↓	↓	↓	↓
Pressions Volumes	Débit cardiaque	RVS	SvO_2

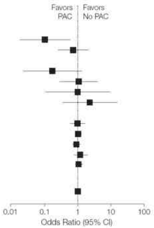




Cathéter artériel pulmonaire et pronostic : impact ?

Figure 2. Odds Ratio (PAC vs No PAC) for Mortality of RCTs Evaluating the Safety and Efficacy of the PAC

Source	No. of Deaths/Total No. of Patients: PAC	No PAC	Odds Ratio (95% CI)
Schultz et al,[15] 1985	1/35	10/35	0.11 (0.02-0.63)
Shoemaker et al,[16] 1988	11/58	7/30	0.76 (0.27-2.15)
Isaacson et al,[17] 1990	1/49	0/53	NA
Berlauk et al,[18] 1991	1/66	2/21	0.18 (0.02-1.42)
Guyatt,[19] 1991	10/16	9/17	1.10 (0.29-4.22)
Bender et al,[20] 1997	1/51	1/53	1.04 (0.11-9.95)
Valentine et al,[21] 1998	3/60	1/60	2.38 (0.35-16.29)
Bonazzi et al,[22] 2002	0/50	0/50	NA
Rhodes et al,[23] 2002	46/95	50/106	1.01 (0.58-1.76)
Sandham et al,[24] 2003	163/997	155/997	1.06 (0.83-1.35)
Richard et al,[25] 2003	199/338	208/343	0.93 (0.68-1.26)
ESCAPE,[10] 2005	45/215	38/218	1.25 (0.78-2.02)
Harvey et al,[14] 2005 (PAC-Man)	346/506	333/507	1.13 (0.87-1.47)
Combined			1.04 (0.90-1.20)

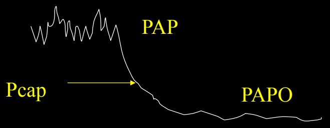


CI indicates confidence inte[…] trial. P for heterogeneity = [...]

Conclusions In critically ill patients, use of the PAC neither increased overall mortality or days in hospital nor conferred benefit. Despite almost 20 years of RCTs, a clear strategy leading to improved survival with the PAC has not been devised. The neutrality of the PAC for clinical outcomes may result from the absence of effective evidence-based treatments to use in combination with PAC information across the spectrum of critically ill patients.

Shah et al JAMA 2005

PAPO : conditions de validité drastiques… et difficiles!



- PAPO < PAPd
- ΔPAPO / Δ PAP < 1.5 = Zone III
- Courbe PAPO = oreillette
- Absence d’onde V de régurgitation
- Attention si forte PEP ou hyperinflation

Cathéter artériel pulmonaire : 20000 lieues sous les mers...

Interprétation d'une courbe de PAPO par des réanimateurs et/ou cardiologues

Score de réussite

The scores were significantly correlated with the number of years of intensive care practice (p < .001), but this association was weak (rho = 0.31) (Figure 1). The scores were also higher if the ICU was affiliated with a university hospital (75.0%) rather than not affiliated with a university hospital (67.8%, p < .0001).

Gnaegi A, Feihl F, Perret C Critical Care Medicine 1997;25:213-220

Echographies par des médecins non spécialistes : les leçons de la « FAST echo"

Surgeon-Performed Ultrasound for the Assessment of Truncal Injuries

Lessons Learned From 1540 Patients

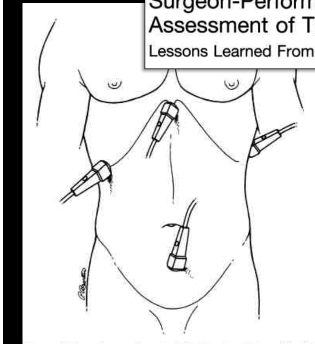


Figure 1. Transducer positions for FAST: (1) pericardial area, (2) right and (3) left upper quadrants, and (4) pelvis.

Focus
Assessment
for the
Sonographic
Examination
of the
Trauma patient

Rozycki et al Ann Surg 1998

Echocardiographie en réanimation : beaucoup de données scientifiques

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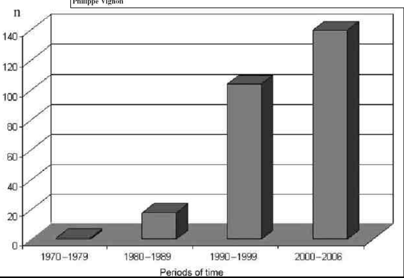
Echocardiography in the intensive care unit: from evolution to revolution?

Fig. 2 Search in PubMed (www.ncbi.nlm.nih.gov/PubMed) for published manuscripts in peer-reviewed journals related to the use of echocardiography in ICU settings during four consecutive periods. The following keywords were used for the Medline search: "Critical Care" [MeSH] AND "Echocardiography" [MeSH], and "Intensive Care" [MeSH] AND "Echocardiography" [MeSH].
n, number



Vieillard Baron et al Intensive Care Med 2007

Prévalence des anomalies cardiaques à l'admission en réanimation

- **467 patients de réanimation médicale; ETT dans les 18 heures suivant l'admission**
- **36 % des patients de réanimation ont une anomalie cardiaque**
  - **22 % : 1 anomalie**
  - **7,2 % : 2 anomalies**
  - **6,8 % : 3 anomalies**
- **77 % des patients ayant anomalie significative échographique n'ont pas été détectés cliniquement**
- **Pas de corrélation anomalie cardiaque / mortalité; mais durée de séjour en réanimation et totale augmentée chez ces patients**

Range and Prevalence of Cardiac Abnormalities in Patients Hospitalized in a Medical ICU

Eduardo Bossone, Bruno DiGiovine, Sara Watts, Pamela A. Marcovitz, Louise Carey, Charles Watts and William F. Armstrong

Chest 2002;122;1370-1376
DOI 10.1378/chest.122.4.1370

Bossone et al *Chest.* 2002;122:1370-1376

Echographie cardiaque trans thoracique et diagnostic incompétence myocardique

Transthoracic Echocardiography To Identify or Exclude Cardiac Cause of Shock

- **100 patients en état de choc**
- **99 sont échogènes**
- **Sensibilité = 100 %**
- **Spécificité = 95 %**
- **VPP = 97 %**
- **VPN = 100 %**

Table 1—*Causes of Cardiogenic Shock*

Causes	No.
Severe LV systolic dysfunction	21
Severe RV systolic dysfunction	9
Severe biventricular systolic dysfunction	8
Tamponade	10
Postinfarction mechanical complication	9
Free-wall rupture	1
Ventricular septal rupture	5
Papillary muscle rupture and severe mitral regurgitation	3
Severe LVOT obstruction	1
Total	63

Table 3—*Change in Management After TTE*

Change in Management	No. of Patients
Medical therapy	29
Surgery	12
Pericardiocentesis	4
Aortic balloon pump	3
Thrombolysis	2
Angioplasty	1

= 51 % de modifications thérapeutiques

Joseph et al *Chest*. 2004

Echographie cardiaque trans thoracique et réanimation « générale »

British Journal of Anaesthesia **102** (3): 340–4 (2009)
doi:10.1093/bja/aen378 Advance Access publication January 18, 2009

BJA

CRITICAL CARE

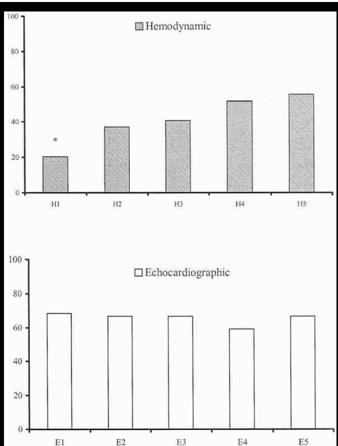
Impact of echocardiography on patient management in the intensive care unit: an audit of district general hospital practice

R. M. L'E. Orme*, M. P. Oram and C. E. McKinstry

Results. Two hundred and fifty-eight echocardiograms were performed in 217 patients, of which 224 (86.8%) were performed by intensive care consultants. One hundred and eighty-seven studies (72.4%) were TTEs and 71 (27.8%) were TOEs. TTE provided diagnostic images in 91.3% of spontaneously breathing and 84.2% of mechanically ventilated patients. Management was changed directly as a result of information provided in 51.2% of studies. Changes included fluid administration, inotrope or drug therapy, and treatment limitation.

Conclusions. Echocardiography may have a significant impact on the management of patients in the general ICU. We recommend that appropriate training in echocardiography should be incorporated into the intensive care curriculum in the UK.

Orme et al Br J Anaesth 2009



The hemodynamically unstable patient in the intensive care unit: Hemodynamic vs. transesophageal echocardiographic monitoring

Costachescu et al **Critical Care Medicine** 2002;30:1214-1223

Chir cardiaque

Figure 1. Diagnostic agreement between each hemodynamic (H1–H5) and echocardiographic (E1–E5) evaluator compared with his or her respective working hypothesis (H0 and E0). H1 had a lower agreement compared with the other hemodynamic evaluators (*p = .001).

Assessment of ventricular function in critically ill patients: limitations of pulmonary artery catheterization. Institutions of the McSPI Research Group.

Fontes ML, Bellows W, Ngo L, Mangano DT. J Cardiothorac Vasc Anesth. 1999 Oct;13(5):521-7

- 25 patients – 130 mesures – post chirurgie cardiaque
- ETO à tous les patients – Altération Fonction VG : FeVG < 40 %
- Clinique + Swan Ganz : 98 % (118/121) de prédictibilité de fonction cardiaque gauche normale
- 0 % (0/9) prédiction de fonction VG anormale par clinique + Swan Ganz

Echographies par des médecins non spécialistes ?

CHEST Consensus Statement

American College of Chest Physicians/ La Société de Réanimation de Langue Française Statement on Competence in Critical Care Ultrasonography*

Paul H. Mayo, MD; Yannick Beaulieu, MD; Peter Doelken, MD; David Feller-Kopman, MD; Christopher Harrod, MS; Adolfo Kaplan, MD; John Oropello, MD; Antoine Vieillard-Baron, MD; Olivier Axler, MD; Daniel Lichtenstein, MD; Eric Maury, MD; Michel Slama, MD; and Philippe Vignon, MD

CONCLUSIONS

The purpose of this document is to define explicitly the competencies of CCUS. This statement has two important uses:

1. It may be used as a practical guide for physicians who seek training and for those who provide training in the field. With this standard statement of competence, the goals of training are now clearly defined.
2. It may be used as a foundation for developing training methods and standards, as well as providing a framework for developing a formal system of certification in the field of CCUS.

Chest 2009

Echocardiographie en réanimation : pyramide des compétences

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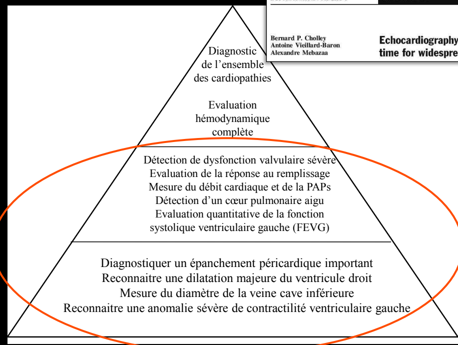
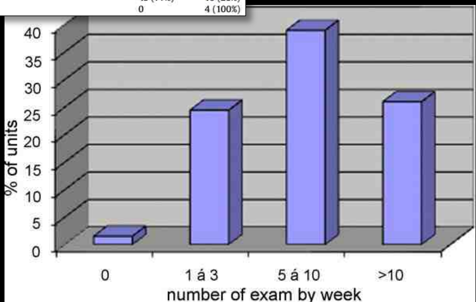
Echocardiography in the ICU: time for widespread use!



Cholley et al Intensive Care Med 2005

Echocardiographie en réanimation en pratique : pas encore le gold standard !

Average mean number of exams per week by type of ICU, n (%)	5–10	>10
Medical	44 (70%)	18 (30%)
Surgical	46 (77%)	16 (23%)
Cardiac surgery	0	4 (100%)



Quintard et al Ann Fr Anesth Reanim 2011

Echocardiographie en réanimation : plus de machines que d'hommes !

Echograph availability by type of centre (percentage responding by type of center)	
University and public community centers	94%
Private centers	79%
Echograph availability by type of ICU, n (percentage responding by type of ICU)	
Medical	58 (96%)
Surgical	56 (89%)
Cardiac surgery	4 (100%)

Number of units with at least one staff member with a diploma, n (%)	
Medical	47 (78)
Surgical	41 (66)
Cardiac surgery	3 (75)

Quintard et al Ann Fr Anesth Reanim 2011

Echocardiographie en réanimation : proposition d'un score de compétence

Validation of a skills assessment scoring system for transesophageal echocardiographic monitoring of hemodynamics

Table 1 Four-part skills assessment scoring system

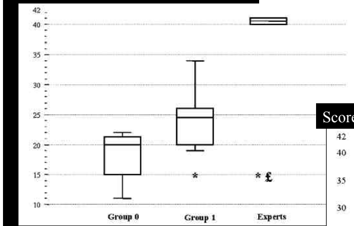
				Score
Qualitative data collection				
Introduction of probe	No	Problematic	Yes	/2
TE Long-axis view at 0°	Not recorded	Not optimal	Optimal	/2
TE Long-axis view at 120°	Not recorded	Not optimal	Optimal	/2
TG Short-axis view at 0°	Not recorded	Not optimal	Optimal	/2
TG Short-axis view at 120°	Not recorded	Not optimal	Optimal	/2
TE View of base of heart at 0°	Not recorded	Not optimal	Optimal	/2
TE View of base of heart at 90°	Not recorded	Not optimal	Optimal	/2
			Total	/14
Semiquantitative data collection				
Mitral regurgitation	None	Moderate	Marked to massive	/2
Aortic regurgitation	None	Moderate	Marked to massive	/2
Dilatation of right ventricle	None	Moderate	Marked	/2
Pericardial effusion	None	Noncompressive	Compressive	/2
Variations in diameter of superior vena cava	None	Minimal	Large	/2
			Total	/10
Quantitative data collection				
	Intensivist		Expert	
E/A ratio				/2
LV FAC (%)				/2
Aortic VTI (cm)				/2
Pulmonary VTI (cm)				/2
			Total	/8
Summary and treatment				
LV contractility	Normal	Moderately decreased	Greatly decreased	/2
Hypovolemia	No		Yes	/2
RV failure	No		Yes	/2
Treatment proposed	Wrong or incomplete		Right	/2
			Total	/8
TEE performed in less than 10 min (yes or no)				/2
Final score				/42

TE, transesophageal; *TG*, transgastric; *FAC*, fractional area change; *LV*, leftventricle; *RV*, right ventricle; *VTI*, velocity–time integral

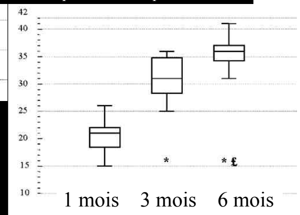
Charron et al Intensive Care Med 2007

Echocardiographie en réanimation : durée d'acquisition des compétences

Score de performance avant formation



Score de performance après formation



Groupe 0 = aucune expérience

Groupe 1 = 1 an de pratique

Charron et al Intensive Care Med 2007

Echocardiographie en réanimation : durée d'acquisition des compétences

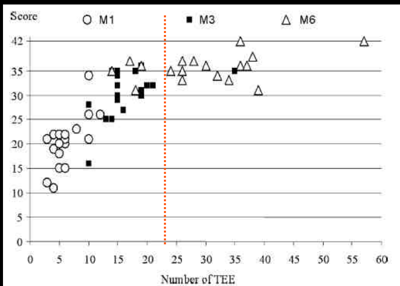


Fig. 3 Relation between the scores obtained and the number of transesophageal echocardiographic examinations done by each intensivist at M1, M3, and M6

Charron et al Intensive Care Med 2007

ETT ou ETO ?

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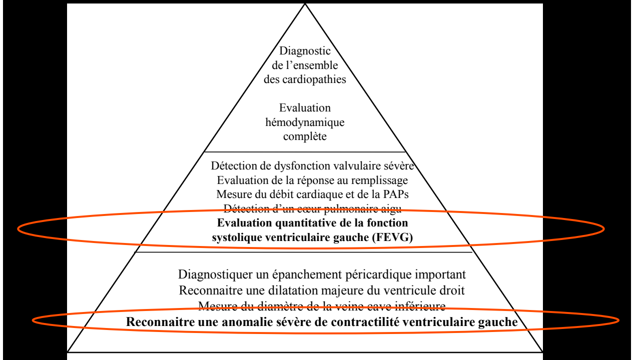
Table 8—*Competence in Advanced CCE: Specific Indications for Advanced CCE**

Suspected Pathology	Echocardiographic Findings
Infectious endocarditis*	Vegetation (size, location), abscess, valvular destruction, quantification of valvular regurgitation
Acute aortic dissection*	Intimal flap (location, extension), signs of extravasation, pericardial effusion, aortic regurgitation
Blunt cardiovascular trauma*	Aortic rupture, mediastinal hematoma, myocardial contusion, and hemopericardium
Cardiovascular source of systemic emboli*	LV apical thrombus, mass in the left atrium/appendage, patent foramen ovale, aortic thrombus, and atherosclerotic lesions
Right-to-left shunt	IV air bubble contrast injection to examine for right-to-left shunt
Pulmonary embolism	Thrombus within pulmonary artery, thrombus in transit through the right heart
Complications of myocardial infarction	RV infarction, LV free wall rupture, papillary muscle rupture

*TEE has higher diagnostic accuracy than TTE for these indications.

Chest 2009

Echocardiographie en réanimation : fonction ventriculaire gauche



Cholley et al Intensive Care Med 2007

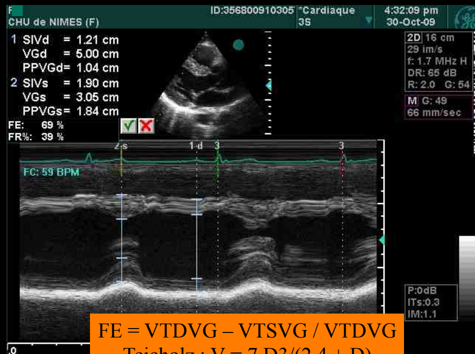
Evaluation de la fonction VG

Fonction VG : évaluation conjointe fonction systolique et diastolique

- Fonction systolique = FEVG
- Fonction diastolique = pressions de remplissage VG

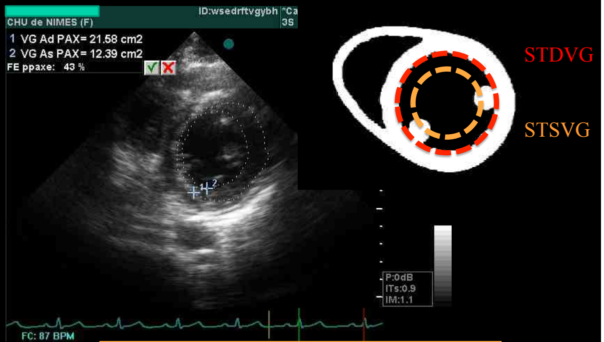
=> Profil mitral
=> Doppler tissulaire
=> Flux veineux pulmonaire

Fonction systolique VG : fraction de raccourcissement en diamètre



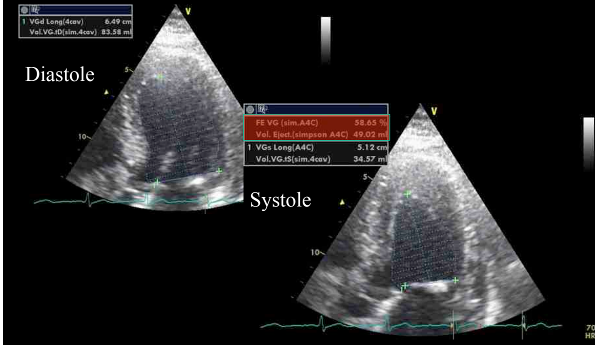
FE = VTDVG – VTSVG / VTDVG
Teicholz : V = 7 D3/(2,4 + D)
D = diamètre VG (PGA en TM)

Fonction systolique VG : fraction de raccourcissement de surface



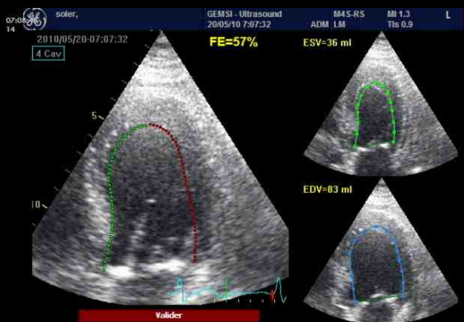
FRS = FEVG = STDVG – STSVG / STDVG

Fonction systolique VG : Méthode de Simpson = volumes Biplan



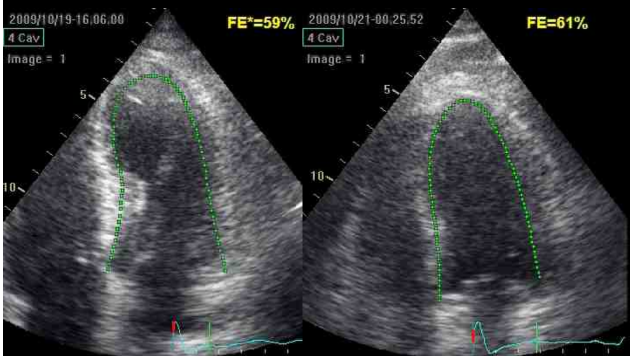
FEVG = VTDVG – VTSVG / VTDVG

Fonction systolique VG : FEVG auto en « speckle tracking »

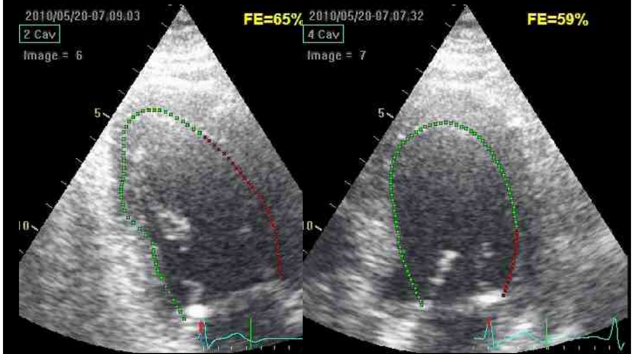


FEVG = VTDVG – VTSVG / VTDVG

FEVG automatique



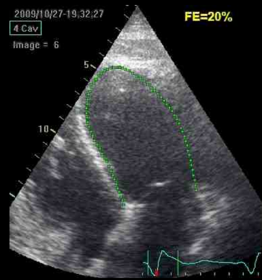
Fonction systolique VG : FEVG auto et 4 cav



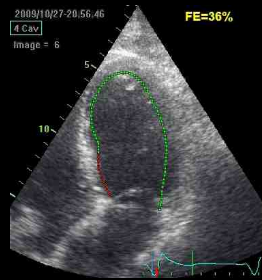
FEVG = VTDVG – VTSVG / VTDVG

Fonction systolique ventriculaire gauche… automatique ?

Choc septique, noradrénaline 3 mcg/Kg/min

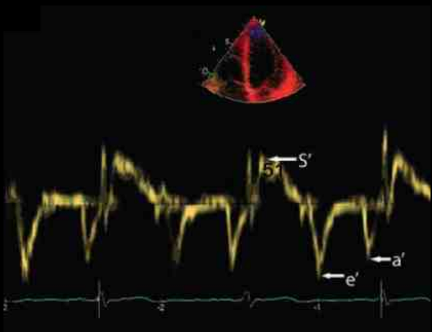


noradrénaline 3 mcg/Kg/min…



+ dobutamine 5 mcg/Kg/min

Fonction systolique VG : *Onde S Doppler tissulaire anneau mitral*



Dalen et al Circulation 2010

Fonction systolique VG : *Onde S Doppler tissulaire anneau mitral*

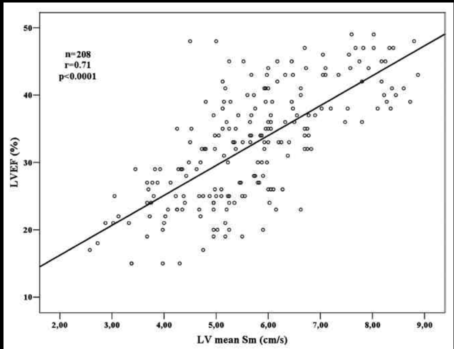
Reference Values and Distribution of Conventional Echocardiographic Doppler Measures and Longitudinal Tissue Doppler Velocities in a Population Free From Cardiovascular Disease

Table 3. Age- and Sex-Specific Mean Annular Velocities by pwTDI and cTDI

	LV (Mean of 4 Walls)			
	S' (pwTDI)	S' (cTDI)	e' (pwTDI)	a' (pwTDI)
Female sex				
Feasibility, no. (%)	652 (98%)	657 (99%)	652 (98%)	652 (98%)
<40 y, cm/s	8.9±1.1	7.2±1.0	14.6±2.3	8.8±1.9
40–60 y, cm/s	8.1±1.2	6.5±1.0	11.3±2.4	10.0±1.9
>60 y, cm/s	7.2±1.2	5.7±1.1	8.2±3.2	10.6±1.9
All, cm/s	8.2±1.3	6.6±1.1	11.8±3.2	9.7±2.0
Male sex				
Feasibility, no. (%)	590 (98%)	601 (99%)	590 (98%)	590 (98%)
<40 y, cm/s	9.4±1.4	7.6±1.2	14.1±2.7	9.1±1.7
40–60 y, cm/s	8.6±1.3	6.9±1.3	10.7±2.3	10.4±1.6
> y, cm/s	8.0±1.3	6.4±1.2	8.2±1.9	11.1±1.6
All, cm/s	8.6±1.4	6.9±1.3	10.8±3.0	10.3±1.7

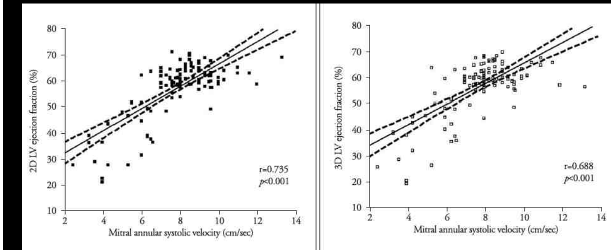
Dalen et al Circulation 2010

Fonction systolique VG : *Onde S Doppler tissulaire*



Duzenli et al JCVU 2010

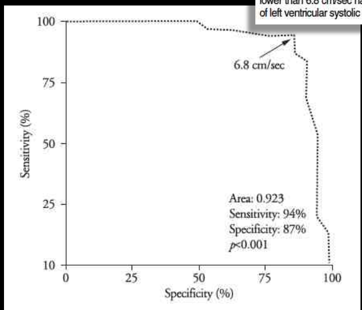
Fonction systolique VG : *Onde S Doppler tissulaire*



Park et al J Clin Ultrasound 2010

Fonction systolique VG : *Onde S Doppler tissulaire*

Fig. 2. Receiver operating characteristic (ROC) curve analysis in detecting left ventricular systolic dysfunction using S' velocity. S' velocity lower than 6.8 cm/sec has the best sensitivity and specificity in detection of left ventricular systolic dysfunction.



Park et al J Clin Ultrasound 2010

Fonction systolique VG : *Onde S Doppler tissulaire*

- Sm entre 6 et 8 cm/s => FEVG = 30 – 49 %
- Sm < 6 cm/s => FEVG < 30 %
- Plus rapide que FEVG
- Meilleure reproductibilité que FEVG

eters in healthy subjects (r = 0.16, not significant). The cutoff value of Sm < 8 cm/s for identifying patients with LVEF between 30% and 49% had a sensitivity of 86%, a specificity of 93%, and a negative predictive value of 92%, and the cutoff value of Sm < 6.0 cm/s for identifying patients with LVEF < 30% had a sensitivity of 92%, a specificity of 84%, and a negative predictive value of 97%. The time required to calculate the LVEF was significantly longer than that of LV mean Sm (327 ± 98 sec vs. 110 ± 29 sec, P < 0.0001), and LVEF had higher inter- and intraobserver variability. LV mean Sm obtained by TDI, a parameter that is reproducible, easily obtained, reliable, and practical,

Duzenli et al JCVU 2010

Dysfonction VG en réanimation : *Simpson non adapté !*

Assessing left ventricular systolic function in shock: evaluation of echocardiographic parameters in intensive care

Table 4 Reproducibility of measurements

	EBEF	Simpson	TDIs	AVPDm	LVOT VTI
Intraobserver	6.8	10.6	8.2	4.4	3.1
Interobserver	9.9	8.2	7.2	5.3	4.8

MAPSE

Conclusions: EBEF and AVPDm provided the best, and Simpson, the worst feasibility when assessing LV systolic function in a population of mechanically ventilated, hemodynamically unstable patients. Additionally, the Simpson showed the poorest repeatability. We suggest that EBEF can be used instead of single-plane Simpson when assessing LV ejection fraction in this category of patients. TDIs and AVPDm, as markers of longitudinal function of the LV, are not interchangeable with LV ejection fraction.

Bergenzaun et al Critical Care 2011

Dysfonction VG en réanimation : *MAPSE et S TDI adaptés !*

Table 2 Correlation (r) between markers of LV systolic function with LV diastolic function and cardiac biomarkers

Mitral annular plane systolic excursion (MAPSE) in shock: a valuable echocardiographic parameter in intensive care patients

	MAPSE		TDIs		LVEF	
	r	p	r	p	r	p
LV systolic function						
LVEF	0.594	<0.001	0.649	<0.001		
LV diastolic function						
é	0.309	0.039	0.341	0.022		ns
E/é	-0.383	0.009		ns		ns
Cardiac biomarkers						
hsTNT	-0.428	0.003		ns		ns
BNP		ns		ns		ns

Spearman rank correlation was used. Statistical significance at p< 0.05.

Bergenzaun et al Cardio vascular US 2013

Dysfonction VG en réanimation : *MAPSE corrélé à la survie au cours des états de choc*

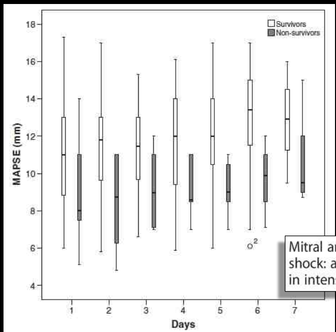


Figure 2 Boxplots of daily measurements show that MAPSE is significantly lower in non-survivors (grey) of 28-day mortality compared to survivors (white) in most days (day 1 p=0.028, day 2 p=0.003, day 3 p=0.060, day 4 p= 0.036, day 5 p=0.026, day 6 p=0.017, day 7 p=0.075). ° Value and case number within 1.5 boxplot length (SPSS 18.0).

Mitral annular plane systolic excursion (MAPSE) in shock: a valuable echocardiographic parameter in intensive care patients

Bergenzaun et al Cardio vascular US 2013

Dysfonction VG en réanimation : *MAPSE ? (AVPDm)*

Assessing left ventricular systolic function in shock: evaluation of echocardiographic parameters in intensive care

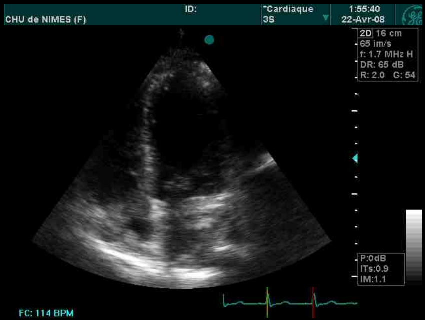
Table 4 Reproducibility of measurements

	Visual	Simpson	TDIs	AVPDm	LVOT VTI
Intraobserver	6.8	10.6	8.2	4.4	3.1
Interobserver	9.9	8.2	7.2	5.3	4.8

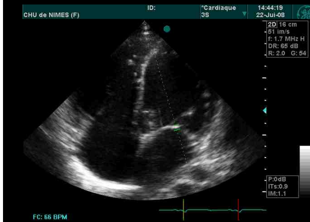
Conclusions: EBEF and AVPDm provided the best, and Simpson, the worst feasibility when assessing LV systolic function in a population of mechanically ventilated, hemodynamically unstable patients. Additionally, the Simpson showed the poorest repeatability. We suggest that EBEF can be used instead of single-plane Simpson when assessing LV ejection fraction in this category of patients. TDIs and AVPDm, as markers of longitudinal function of the LV, are not interchangeable with LV ejection fraction.

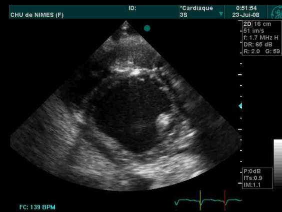
Bergenzaun et al Critical Care 2011

Fonction systolique VG



Fonction systolique VG



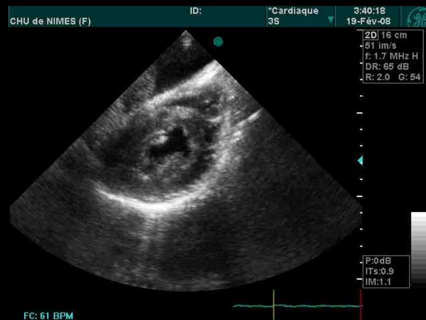


Patient de 34 ans, OH chronique +++, coma éthylique + choc

Fonction ventriculaire gauche…

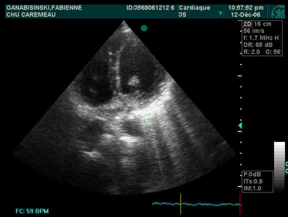
Patient de 25 ans, fracture du bassin, état de choc

Fonction ventriculaire gauche…



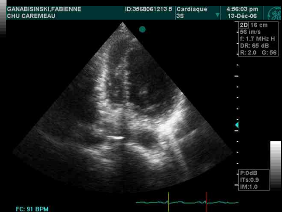
Patient de 25 ans, choc septique

Fonction systolique VG en réa : la vraie vie…



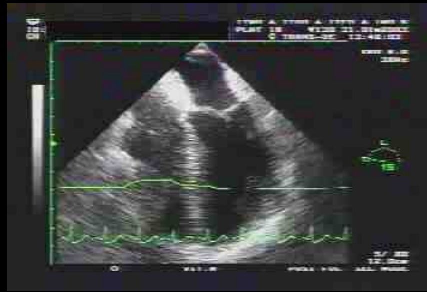
Patiente 38 ans, coma, choc
Intoxication volontaire
PA = 80/60

Carbamates positifs



J1, dobutamine

Fonction VG et choc septique

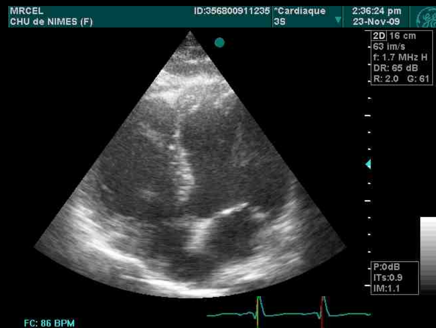


Vieillard-Baron et al AJRCCM 2003

Echocardiographie et choc septique

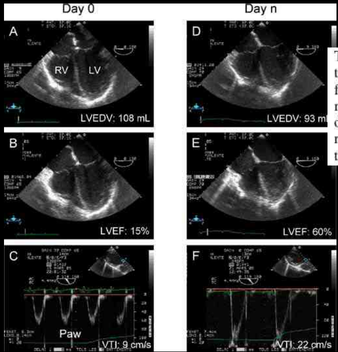
Vieillard-Baron et al AJRCCM 2003

Echocardiographie et choc septique : *défaillance VD <u>et</u> VG possible*



Chc septique noradrénaline 1,2 mcg / Kg / min

Choc septique et dysfonction systolique VG = 20% des cas
Réversible, n'est pas un critère de mauvais pronostic



This study confirms that LV systolic and diastolic dysfunctions are frequent, but LV dilatation is uncommon in fluid-loaded septic patients on vasopressors. All abnormalities regressed in survivors, regardless of their severity. *Descriptors:* Shock:

Etchecopar-Chevreuil et al Intensive Care Med 2008

Dysfonction VG en réa : l'évaluation qualitative visuelle est valable

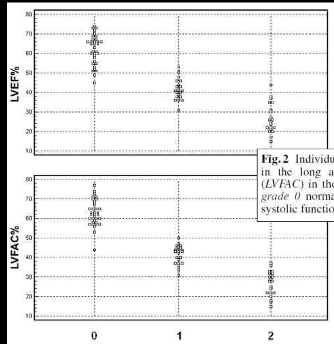


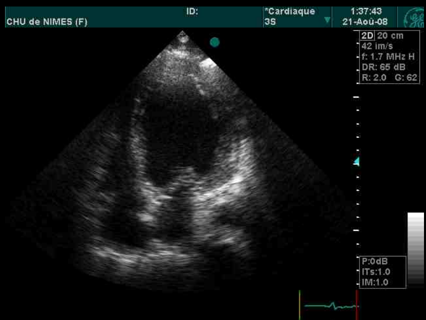
Fig. 2 Individual values of left ventricular ejection fraction (*LVEF*) in the long axis (*above*) and left ventricular area contraction (*LVFAC*) in the short axis (*below*) in the three qualitative groups: *grade 0* normal systolic function; *grade 1* moderately depressed systolic function; *grade 2* severely depressed systolic function

Grand axe

Petit axe

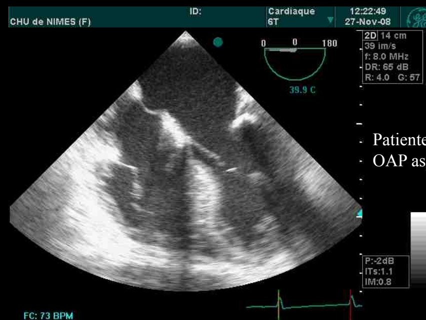
Vieillard Baron et al Intensive Care Med 2006

Fonction systolique VG : ne suffit pas…



Patient 78 ans,
Détresse respiratoire
Crépitants
T° = 38°

Fonction systolique VG : ne suffit pas…



Patiente de 78 ans,
OAP asphyxique

Insuffisance cardiaque à fonction systolique préservée = 50 % des OAP

- Signes cliniques d'insuffisance cardiaque gauche
- FEVG normale
- Pressions gauches élevées

- Registre ADHERE
- 100 000 patients en OAP
- 52 000 ont une fonction systolique préservée

=> Importance de l'évaluation des pressions gauches

Yancy et al J Am Coll Cardiol 2006
Kumar et al Crit Care Med 2008

OAP ou SDRA ? : définition

- Début brutal

- Opacités parenchymateuses bilatérales

- Absence d'évidence clinique d'hypertension auriculaire gauche ou PAPO < 18 mmHg

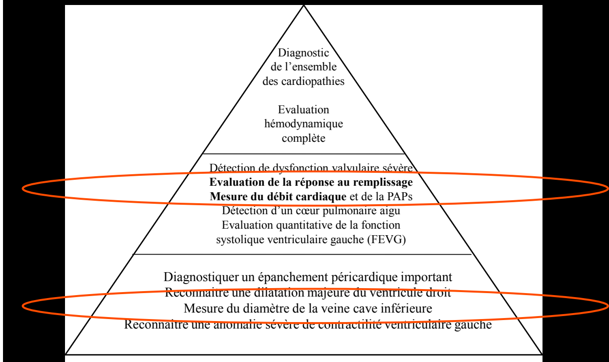
- PaO2/FiO2 < 300 = Acute Lung Injury

- PaO2/FiO2 < 200 = ARDS

Bernard et al Intensive Care Med 1994
Artigas et al AJRCCM 1998
Berlin 2012

Evaluation des pressions de remplissage
Evaluation de la réponse à l'expansion volémique

Echocardiographie en réanimation : évaluation des pressions de remplissage



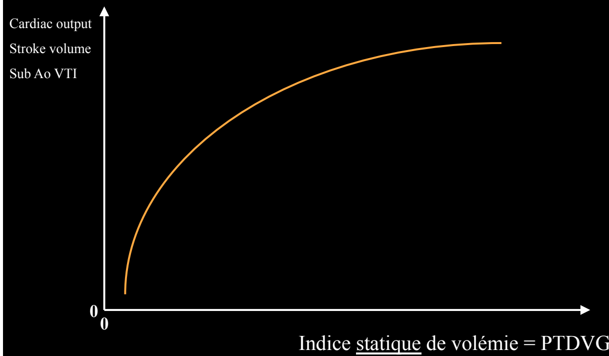
Cholley et al Intensive Care Med 2007

Première étape – approche statique

Evaluation de la PTDVG

Pressions de remplissage et débit cardiaque :

Courbe de Frank-Starling



Réponse à l'expansion volémique : *définition « moderne »*

Recommandations d'experts de la SRLF
« Indicateurs du remplissage vasculaire au cours de l'insuffisance circulatoire »

- L'efficacité d'un remplissage vasculaire se juge sur le volume d'éjection systolique (accord fort).

- L'augmentation de plus de 10–15 % du volume d'éjection systolique et/ou du débit cardiaque permet de différencier les patients répondeurs à un remplissage vasculaire (accord fort).

Teboul et al, Réanimation 2004

You Need a step by step approach !

La moitié des épreuves de remplissage sont négatives

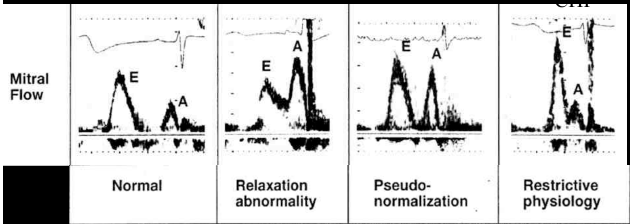
… l'écho peut elle nous aider ?

	R / NR	Response to fluid (%)
Calvin (Surgery 81)	20 / 8	71 %
Schneider (Am Heart J 88)	13 / 5	72 %
Reuse (Chest 90)	26 / 15	63 %
Magder (J Crit Care 92)	17 / 16	52 %
Diebel (Arch Surgery 92)	13 / 9	59 %
Diebel (J Trauma 94)	26 / 39	40 %
Wagner (Chest 98)	20 / 16	56 %
Tavernier (Anesthesio 98)	21 / 14	60 %
Magder (J Crit Care 99)	13 / 16	45 %
Tousignant (A Analg 00)	16 / 24	40 %
Michard (AJRCCM 00)	16 / 24	40 %
Feissel (Chest 01)	10 / 9	53 %
Mean	**211 / 195**	**52 %**

Michard et al Chest 2002

Evaluation statique de la PTDVG:

Mitral Flux = fonction diastolique



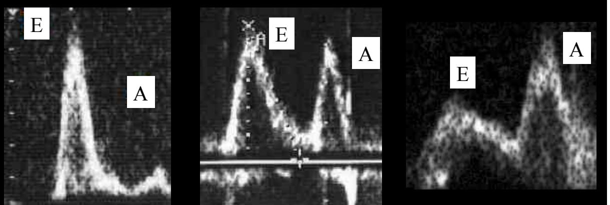
Aurigemma et al NEJM 2004
Sagie et al. JASE 1993

Flux mitral : influence de l' âge

Sujet jeune
E/A>2
TDE court

Age moyen

Sujet âgé

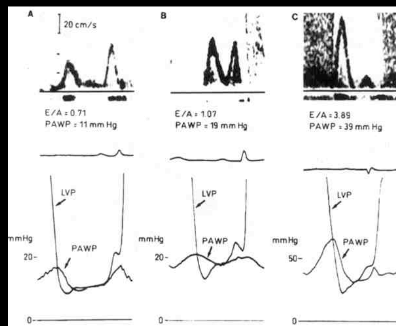


Rapport E/A < 1 chez 85% des sujets > 70 ans

Aurigemma et al NEJM 2004
Sagie et al. JASE 1993

Evaluation statique de la PTDVG:

Le profil mitral est corrélé à la PTDVG

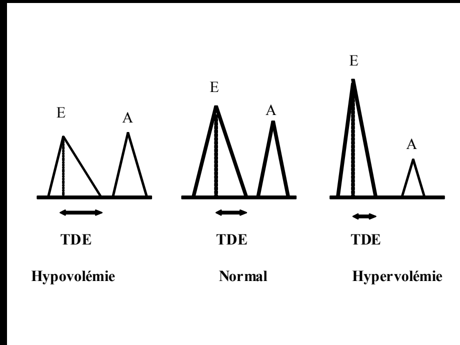


Vanoverschelde et al Am J Cardiol 1995

E wave velocity :
What we need to know about E wave is

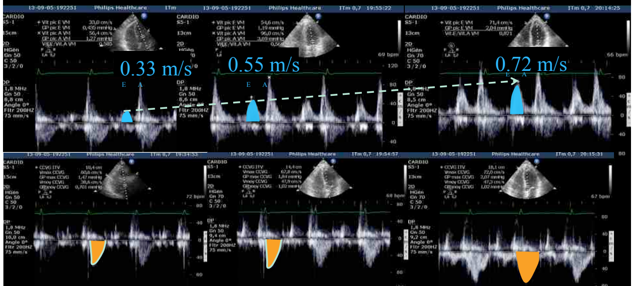
• Normal E wave velocity = 0,7 – 0,9 m/s

Flux mitral : variations avec la volémie



Evaluation statique de la PTDVG:
L'onde E varie avec la volémie

Femme de 72 ans, choc, péritonite

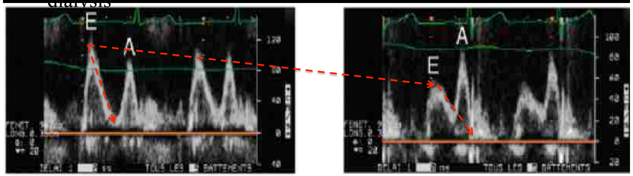


VTI 10 14 18

Avant remplissage 500 mL 100

Evaluation statique de la PTDVG:
L'onde E varie avec la volémie

3000 ml fluid removal



Vignon et al Crit Care 2007

Vitesse de l'onde E :
HYPOVOLEMIE ***si*** *< 0.75 m/s ??*

Table 1. Characteristics of the general population and comparison between Responders and Nonresponders at baseline (before fluid challenge)

	All patients (n = 40)	Responders (n = 20)	Nonresponders (n = 20)	p value -
Age (years)	63 (56-70)	61 (49-70)	66 (53-75)	0.58
Weight (Kg)	72 (65-77	67 (63-76)	76 (63-88)	0.14
Height (cm)	169 (164-173)	170 (162-176)	168 (160-173)	0.38
APACHE II score	17 (14-23)	18 (14-29)	14 (11-21)	0.30
HR (bpm)	101 (91-116)	101 (91-125)	103 (79-121)	0.78
MAP (mmHg)	71 (66-77)	70 (61-88)	72 (65-87)	0.56
LVEF (%)	55 (50-60)	55 (50-60)	55 (47-60)	0.41
VTI (cm)	16 (14-18)	14 (12-16)	17 (15-21)	< 0.01
E velocity (cm/s)	75 (70-80)	65 (53-76)	82 (75-93)	< 0.01
E/A velocity ratio	0,9 (0,8-1,1)	0,8 (0,6-1,1)	1,0 (0,8-1,4)	< 0.01
Ea velocity (cm/s)	12 (10-13)	12 (9-14)	11 (9-15)	0.79
E/Ea velocity ratio	6 (5-8)	5 (5-10)	7 (5-8)	0.40
cIVC (%)	34 (16-64)	64 (28-100)	19 (5-35)	< 0.01

Muller et al Critical Care 2012

Vélocité de l'onde E :
Evalue la PTDVG, même en cardiologie

New, Simple Echocardiographic Indexes for the Estimation of Filling Pressure in Patients with Cardiac Disease and Preserved Left Ventricular Ejection Fraction

... incremen-tal accuracy to E/Ea alone in patients with E/Ea in the gray zone. Finally, in this population, E <60 cm/sec ruled out, and E>90 cm/sec ruled in, elevated LVEDP with high negative and positive predictive values, respectively, which, in the right clinical setting, may be useful screening tools in this population for the presence of DHF.

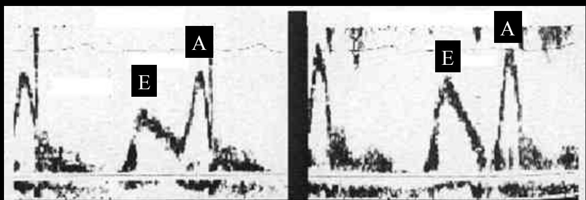
E < 60 cm/s => Low LVEDP

E > 90 cm/s => High LVEDP

Dokainish et al Echocardiography 2010

Flux mitral : influence de la volémie

Sujet jeune hypotendu



Avant remplissage

Après remplissage
E ↗
TDE ↘

ECHOGRAPHIE CARDIAQUE EN REANIMATION : Précharge

preserved LVEF. (E+LAVi)/2 provides incremen-tal accuracy to E/Ea alone in patients with E/Ea in the gray zone. Finally, in this population, E <60 cm/sec ruled out, and E>90 cm/sec ruled in, elevated LVEDP with high negative and positive predictive values, respectively, which, in the right clinical setting, may be useful screening tools in this population for the presence of DHF.

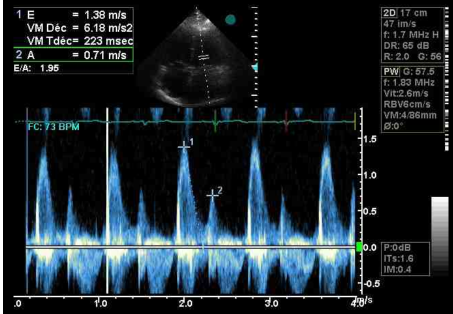
Dans une population de patients avec cardiopathie connue :

E < 60 cm/s => PAPO basse

E > 90 cm/s => PAPO haute

Dokainish et al Echocardiography 2010

ECHOGRAPHIE CARDIAQUE EN REANIMATION : Précharge



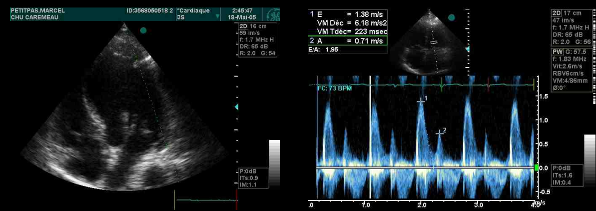
E/A ratio > 2 (pic)
=
PAPO > 18 mmHg

(VPP = 100 %)

Boussuges et al Critical care medicine 2002;30:362-367

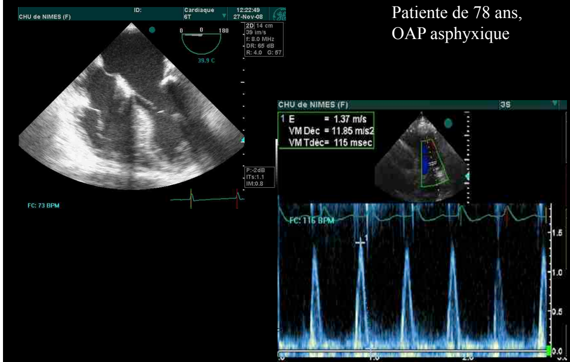
Fonction systolique VG ne suffit pas à affirmer l' OAP cardiogénique

Patient 78 ans,
Détresse respiratoire
Crépitants
T° = 38°

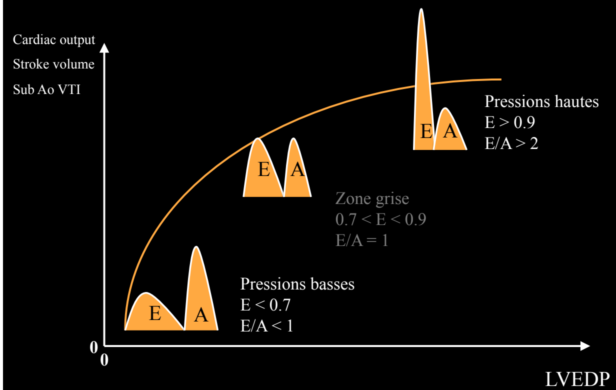


Fonction systolique VG : ne suffit pas…

Patiente de 78 ans,
OAP asphyxique

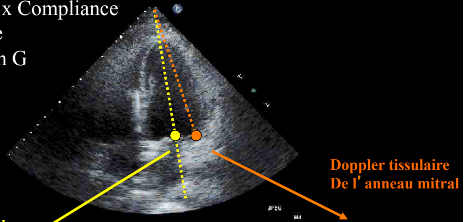


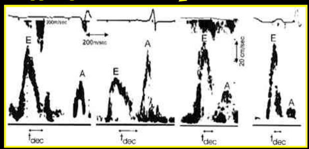
Evolution du profil mitral avec la volémie

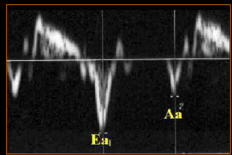


Mesure des pressions de remplissage : Doppler tissulaire

E = Pression (G) x Compliance
E' = Compliance
E / E' = Pression G

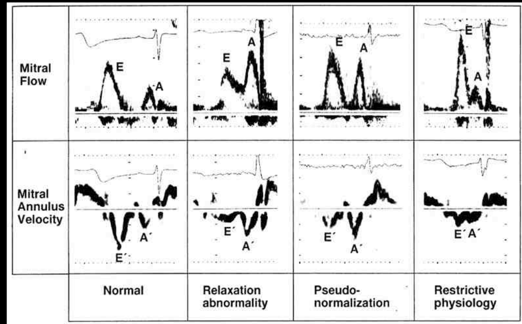






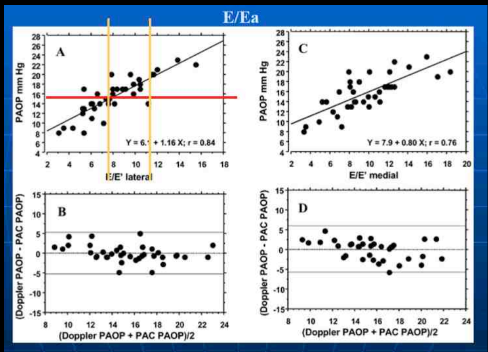
E/Ea élevé : pressions de remplissage hautes

Doppler mitral, Doppler tissulaire, fonction diastolique et pressions de remplissage : ... *Synthèse*



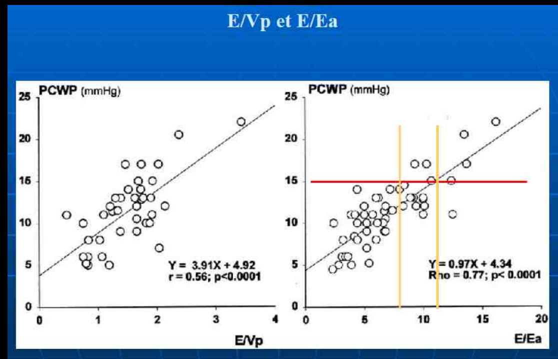
Onde E' < 8 cm/s => dysfonction diastolique

Rapport E/E' et pressions gauches en réanimation



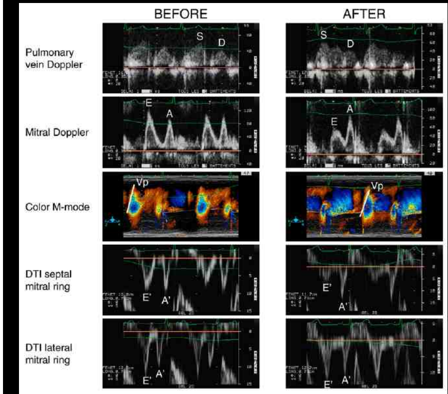
Combes et al Intensive Care Med 2004

Rapport E/E' et pressions gauches en réanimation



Bouhemad et al Anesthesiology 2003

TDI en réanimation : à l'anneau latéral ?



ETT per hémodialyse

Perte moyenne : 3 litres

Vignon et al Crit Care 2007

TDI en réanimation : *Onde E' précharge dépendante !*

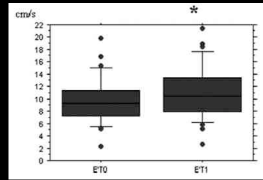
Influence of Acute Preload Changes on Mitral Annulus Velocity Measured by Tissue Doppler Echocardiography in Critically Ill Patients

Hervé Quintard, MD,[1] Laurent Muller, MD,[2] Ivan Philip, MD,[3] Pierre Lena, MD,[4] Carole Ichai, MD, PhD[1]

TABLE 2
Echocardiographic Data Before and After Fluid Infusion (median ± interquartile range)

	Before Fluid Infusion (T0)	1 hour After Fluid Infusion (T1)	*p*
E mitral velocity (cm/s)	50.5 ± 25.9	62.6 ± 21.9	0.001
A mitral velocity (cm/s)	54.5 ± 21	53.3 ± 19	ns
E/A ratio	1.04 ± 0.5	1.2 ± 0.5	ns
E′ lateral mitral velocity (cm/s)	9.3 ± 3.8	10.5 ± 4.3	0.02
A′ lateral mitral velocity (cm/s)	8.5 ± 4.3	9.5 ± 4.7	ns
E/e′ lateral ratio	6.6 ± 3.8	7.2 ± 2.9	ns
E′ septal mitral velocity (cm/s)	7.5 ± 2.5	9.1 ± 3.8	<0.05
A′ septal mitral velocity (cm/s)	6.9 ± 2.8	9 ± 3.8	<0.05
E/e′ septal ratio	6.7 ± 7	6.8 ± 5	ns
LV area (cm^2)	17.2 ± 5.4	18.5 ± 5.5	<0.05

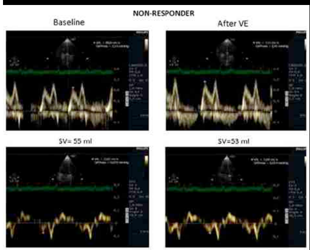
Le rapport E/E' en réanimation n'est pas fiable pour les pressions BASSES



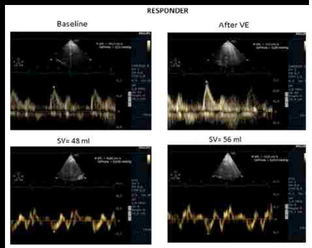
Quintard et al JCU 2011

TDI en réanimation : *Onde E' précharge dépendante !*

Non réponse au RV : E' inchangée sous remplissage



Réponse au RV : augmentation de E' sous remplissage



Mahjoub et al Intensive Care Med 2013

TDI en réanimation : *Onde E' précharge dépendante !*

Variation de + 30% de la vélocité de E' sous remplissage chez les répondeurs au remplissage
Variation de 5 % chez les non répondeurs

Table 4 Comparison of VE–induced variation (Δ) of haemodynamic data between the two groups for patients with left ventricular diastolic dysfunction at baseline (E′ wave <0.12 m/s)

VE-induced variation in haemodynamic parameters	Responders ($n = 33$)	Non-responders ($n = 14$)	*p*
ΔHR % (bpm)	−5 ± 1 (−5 ± 1)	−4 ± 2 (−3 ± 2)	0.43
ΔSAP % (mmHg)	13 ± 3 (12 ± 3)	4 ± 3 (4 ± 2)	0.10
ΔDAP % (mmHg)	8 ± 4 (5 ± 3)	1 ± 2 (1 ± 2)	0.07
ΔMAP % (mmHg)	9 ± 3 (7 ± 3)	3 ± 4 (2 ± 3)	0.09
ΔCVP % (mmHg)	23 ± 15 (2.4 ± 0.9)	36 ± 16 (3.5 ± 1.1)	0.56
ΔSV % (ml)	31 ± 2 (16 ± 1)	−3 ± 3 (−2 ± 2)	<0.001
ΔCO % (l/min)	24 ± 3 (1.2 ± 0.1)	−4 ± 4 (−0.2 ± 0.2)	<0.001
ΔLVEDA % (cm^2)	13 ± 6 (3.0 ± 1.0)	−5 ± 8 (−2.5 ± 1.5)	0.04
ΔE wave % (m/s)	27 ± 7 (0.17 ± 0.03)	42 ± 11 (0.17 ± 0.05)	0.25
ΔA wave % (m/s)	11 ± 3 (0.08 ± 0.02)	−3 ± 5 (−0.02 ± 0.04)	0.03
ΔE/A ratio %	18 ± 1 (0.13 ± 0.05)	6 ± 17 (0.28 ± 0.08)	0.04
ΔEDT % (ms)	−4 ± 5 (−37 ± 13)	−14 ± 6 (−61 ± 18)	0.18
ΔE′ wave % (m/s)	29 ± 5 (0.022 ± 0.004)	5 ± 8 (0.005 ± 0.006)	0.01
ΔA′ wave % (m/s)	27 ± 17 (0.02 ± 0.02)	83 ± 28 (0.10 ± 0.04)	0.10
ΔE/E′ %	2 ± 6 (0.03 ± 0.39)	35 ± 9 (1.75 ± 0.61)	0.02
ΔTei index %	−25 ± 11(−0.20 ± 0.06)	4 ± 8 (−0.02 ± 0.10)	0.01
ΔEF %	0.1 ± 1.5 (−0.1 ± 0.9)	−6 ± 2 (−4.0 ± 1.0)	0.06
ΔS′ wave % (m/s)	6 ± 5 (0.06 ± 0.05)	1 ± 8 (0.01 ± 0.09)	0.63

Mahjoub et al Intensive Care Med 2013

TDI en réanimation : *Onde E' précharge dépendante !*

Variation de + 35% de E/E' chez les non répondeurs sous remplssage
=> Bon indice pour <u>les pressions hautes</u>

Table 4 Comparison of VE–induced variation (Δ) of haemodynamic data between the two groups for patients with left ventricular diastolic dysfunction at baseline (E′ wave <0.12 m/s)

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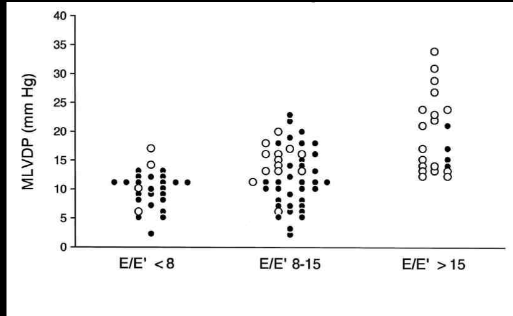
Mahjoub et al Intensive Care Med 2013

Rapport E/E' : *surtout utile pour les pressions hautes ++++*

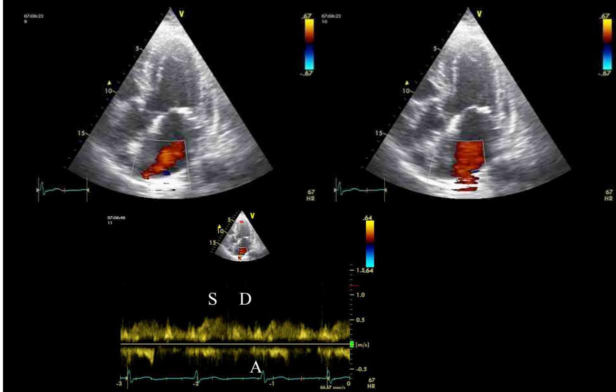


Ommen et al Circulation 2000

Pressions gauches en réanimation : résumé

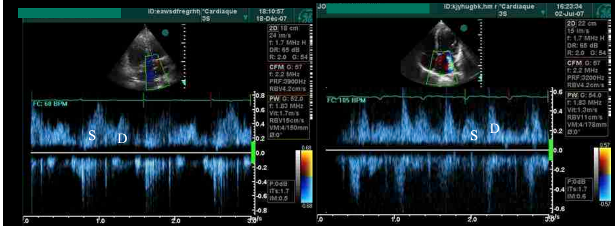
- Onde E < 0,7 m/s : pressions basses
- Onde E > 0,9 m/s : pressions hautes
- Onde E' < 8 cm/s : fonction diastolique très altérée
- E/E' < 7 : pressions basses : <u>mais mauvais indice pour décider de remplir</u>
- E/E' > 11 : pressions hautes
- Variation de E' sous remplissage = hypovolémie
- E/A > 2 : pressions hautes

Flux veineux pulmonaire



Précharge haute : inversion du flux veineux pulmonaire

Flux veineux pulmonaire en réanimation



Normal

Pressions hautes

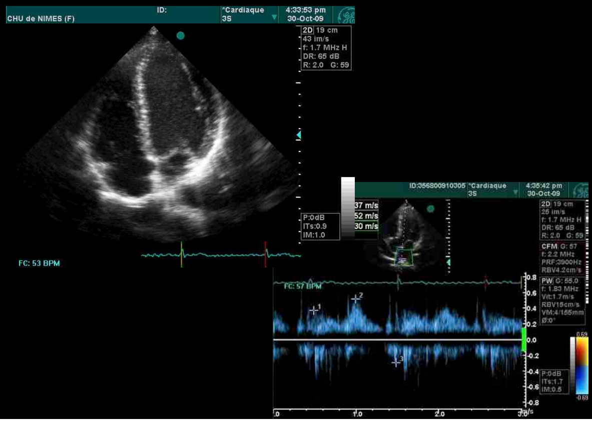
Boussuges et al Crit care Med 2002

Flux veineux pulmonaire : influence de l'âge

Rapport S/D = 0,8 – 1,4

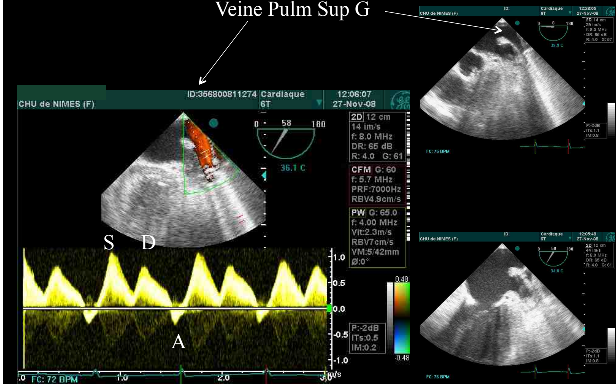
Âge	2-20 ans	21-40 ans	41-60 ans	> 60 ans
Rapport S/D	0,82 ± 0,18	0,98 ± 0,32	1,21 ± 0,2	1,39 ± 0,47
Pic Ar (cm/s)	16 ± 10	21 ± 8	23 ± 3	25 ± 9
Durée Ar (ms)	66 ± 39	96 ± 33	112 ± 15	113 ± 30

Flux veineux pulmonaire : *sujet jeune, sportif : inversion physiologique*



Flux veineux pulmonaire en pratique : facile en ETO

Veine Pulm Sup G



Flux veineux pulmonaire en réanimation :
Fraction systolique < 40 % = PAPO < 12 mmHg

FS : ITV S / (ITV S + ITV D)

Table 6. Positive predictive value of different Doppler indexes for the prediction of elevated pulmonary artery occlusion pressure (PAOP), %

PAOP (mm Hg) more than	6	8	12	15	18	21	24
E/A ratio >2	100	100	100	100	100	67	67
Systolic fraction of pulmonary forward flow <0.4	100	100	100	82	55	45	18
Duration of PV A-wave > duration of mitral A-wave	83	83	83	83	67	50	33

Boussuges et al Crit Care Med 2002

Evaluation statique de la PTDVG:
Tous les indices de cardiologie ne sont pas exploitables en réa

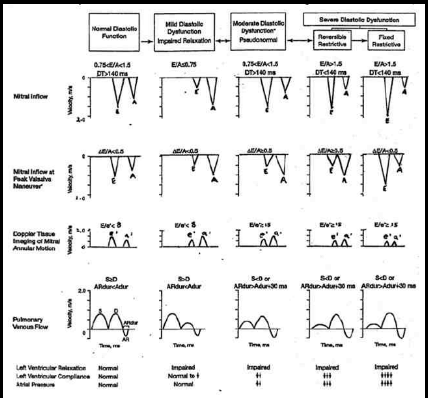
Inter-observer and intra-observer variability in Doppler measurements

	IVRT	V_{max} E	V_{max} A	DT_E	V_{max} S	V_{max} D	V_{max} E' septal	V_{max} E' lateral	Vp
Inter-observer[a]	10%	1%	3%	13%	4%	5%	4%	5%	11%
r[b]	0.34 (-0.13 to +0.68)	0.99 (0.98–1.0)	0.98 (0.95–0.99)	0.31 (-0.15 to +0.66	0.86 (0.63–0.95)	0.87 (0.65–0.96)	0.97 (0.91–0.99)	0.93 (0.82–0.97)	0.22 (-0.27 to +0.62)
Intra-observer[a]	6%	2%	2%	7%	4%	6%	2%	2%	7%
r[b]	0.85 (0.65–0.94)	0.98 (0.94–0.99)	0.98 (0.95–0.99)	0.72 (0.42–0.88)	0.87 (0.67–0.95)	0.74 (0.41–0.90)	0.93 (0.83–0.97)	0.95 (0.87–0.98)	0.54 (0.12–0.80)

[a]Mean percentage error. [b]Intraclass coefficient correlation (numbers in parentheses are 95% confidence intervals). IVRT, isovolumic relaxation time; V_{max}, maximal velocity; DT_E, E wave deceleration time; Vp, propagation velocity.

Vignon et al Crit Care 2007

Fonction diastolique, pressions de remplissage : résumé

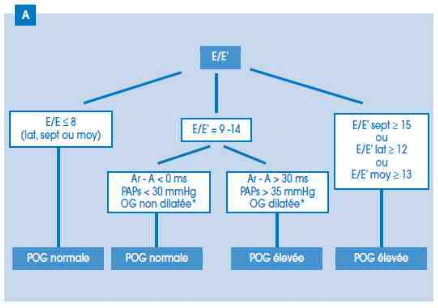


Attention :ETO
Flux mitral
inversé

JAMA 2003

Fonction diastolique, pressions de remplissage : résumé

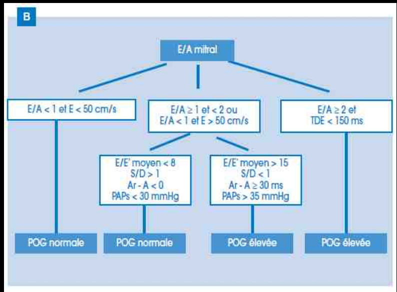
FEVG normale



Nagueh et al Eur J Echocardiog 2009

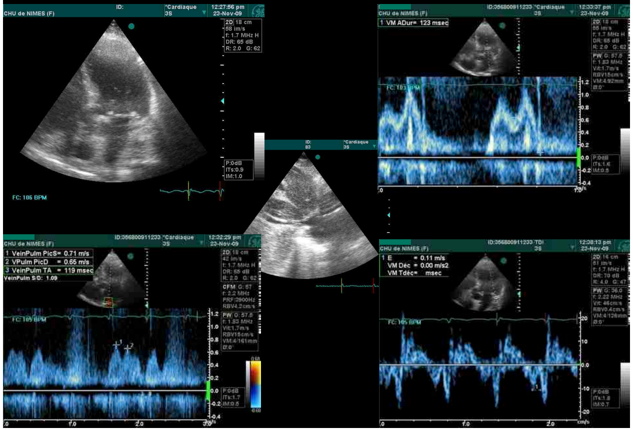
Fonction diastolique, pressions de remplissage : résumé

FEVG basse

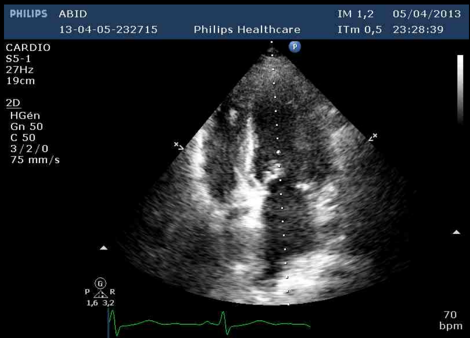


Nagueh et al Eur J Echocardiog 2009

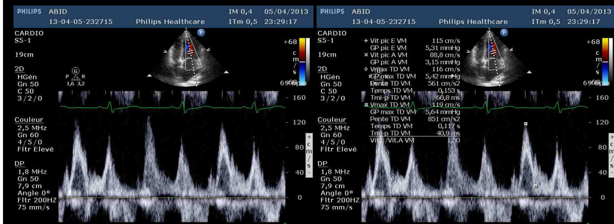
Patient de 67 ans, dyspnée spastique, BPCO 40 PA



Patiente de 72 ans, greffée, dyspnée, oligurie, PA correcte

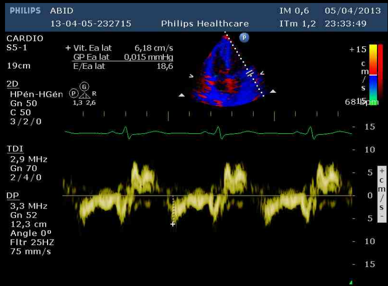


Patiente de 72 ans, greffée, dyspnée, oligurie, PA correcte
Doppler mitral

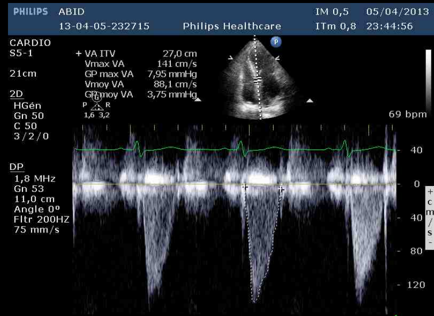


Patiente de 72 ans, greffée, dyspnée, oligurie, PA correcte

Doppler tissulaire

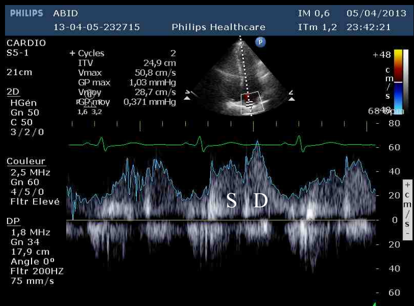


Patiente de 72 ans, greffée, dyspnée, oligurie, PA correcte

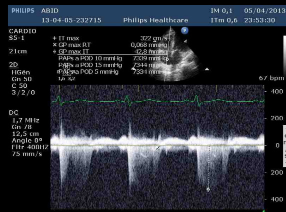


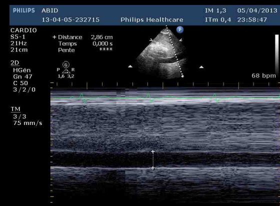
Ce patient a tous les critères de pressions hautes, plus un débit haut => lasilix

Patiente de 72 ans, greffée, dyspnée, oligurie, PA correcte



Patiente de 72 ans, greffée, dyspnée, oligurie, PA correcte





Gradient Vd-AP = 43 mmHg PVC = 15 – 20 mmHg

Ici : PAPS = 55-60 mmHg pour une normale < 35 => HTAP!!
Ce patient a tous les critères de pressions hautes => lasilix