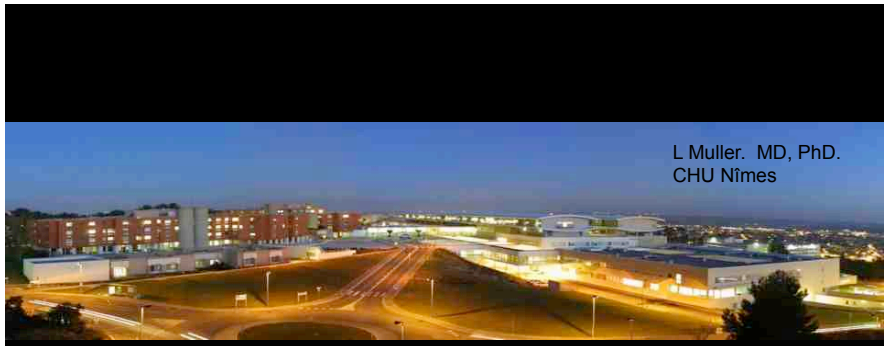


L Muller. MD, PhD.
CHU Nîmes

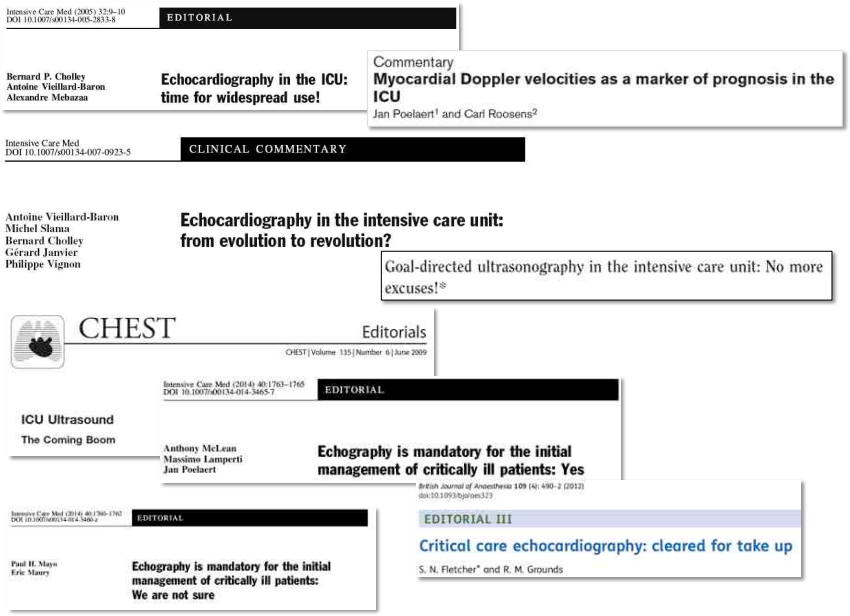
Echocardiographie aux urgences et en anesthésie réanimation :

Comment l'utiliser ?

AZUREA

Université Montpellier 1 Faculté de Médecine

CHU



Intensive Care Med (2005) 32:9–10
DOI 10.1007/s00134-005-2833-8

EDITORIAL

Bernard P. Cholley
Antoine Vieillard-Baron
Alexandre Mebazaa

Echocardiography in the ICU: time for widespread use!

Commentary

Myocardial Doppler velocities as a marker of prognosis in the ICU

Jan Poelaert[1] and Carl Roosens[2]

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

CLINICAL COMMENTARY

Antoine Vieillard-Baron
Michel Slama
Bernard Cholley
Gérard Janvier
Philippe Vignon

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

Goal-directed ultrasonography in the intensive care unit: No more excuses!*

CHEST

Editorials

CHEST | Volume 135 | Number 6 | June 2009

Intensive Care Med (2014) 40:1763–1765
DOI 10.1007/s00134-014-3465-7

EDITORIAL

ICU Ultrasound
The Coming Boom

Anthony McLean
Massimo Lamperti
Jan Poelaert

Echography is mandatory for the initial management of critically ill patients: Yes

British Journal of Anaesthesia 109 (4): 490–2 (2012)
doi:10.1093/bja/aes323

Intensive Care Med (2014) 40:1760–1762
DOI 10.1007/s00134-014-3466-6

EDITORIAL

Paul H. Mayo
Eric Maury

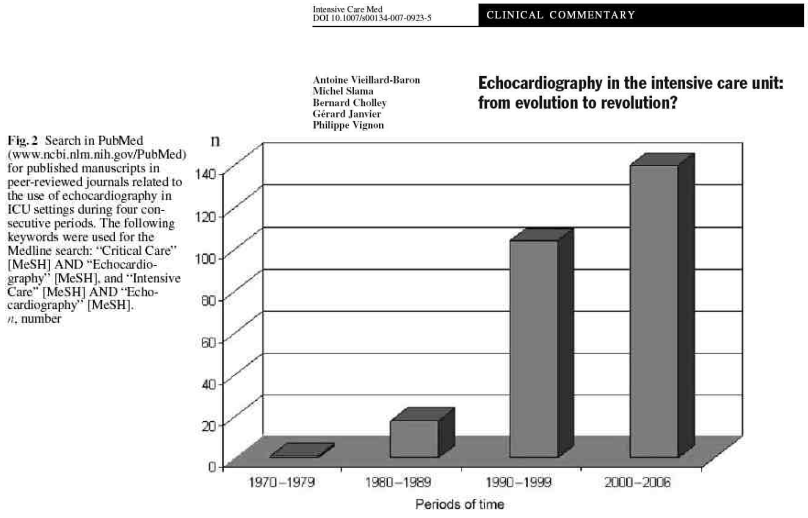
Echography is mandatory for the initial management of critically ill patients: We are not sure

EDITORIAL III

Critical care echocardiography: cleared for take up

S. N. Fletcher* and R. M. Grounds

Echocardiographie en réanimation : *beaucoup de données scientifiques*



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CLINICAL COMMENTARY

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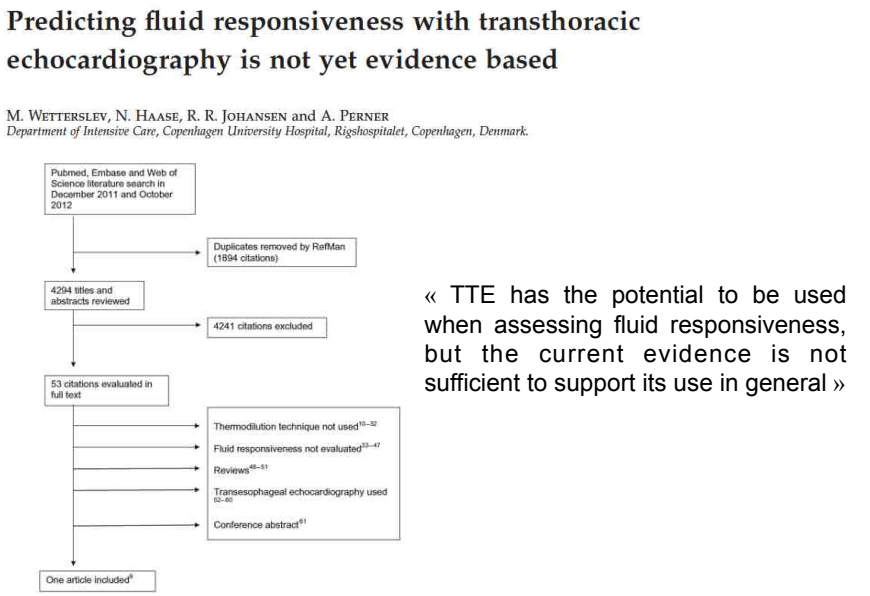
Echocardiography in the intensive care unit: from evolution to revolution?

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



Predicting fluid responsiveness with transthoracic echocardiography is not yet evidence based

M. Wettersley, N. Haase, R. R. Johansen and A. Perner
Department of Intensive Care, Copenhagen University Hospital, Rigshospitalet, Copenhagen, Denmark.

« TTE has the potential to be used when assessing fluid responsiveness, but the current evidence is not sufficient to support its use in general »

Acta Anaesthesiol Scand 2013; **57**: 692–697

Les trois questions hémodynamiques en réanimation

100 % de remplissage – 50 % vasopresseur – 15 % d'inotropes

TABLE 4. TREATMENTS ADMINISTERED.*

TREATMENT	HOURS AFTER THE START OF THERAPY		
	0–6	7–72	0–72
Total fluids (ml)			
Standard therapy	3499±2438	10,602±6,216	13,358±7,729
EGDT	4981±2984	8,625±5,162	13,443±6,390
P value	<0.001	0.01	0.73
Red-cell transfusion (%)			
Standard therapy	18.5	32.8	44.5
EGDT	64.1	11.1	68.4
P value	<0.001	<0.001	<0.001
Any vasopressor (%)†			
Standard therapy	30.3	42.9	51.3
EGDT	27.4	29.1	36.8
P value	0.62	0.03	0.02
Inotropic agent (dobutamine) (%)			
Standard therapy	0.8	8.4	9.2
EGDT	13.7	14.5	15.4
P value	<0.001	0.14	0.15
Mechanical ventilation (%)			
Standard therapy	53.8	16.8	70.6
EGDT	53.0	2.6	55.6
P value	0.90	<0.001	0.02
Pulmonary-artery catheterization (%)‡			
Standard therapy	3.4	28.6	31.9
EGDT	0	18.0	18.0
P value	0.12	0.04	0.01

100 % de fluides

30 à 50 % de vasopresseurs

15 % d'inotropes

Rivers et al N Engl J Med 2001
Myburgh et al NEJM 2012

Une session classique d'échocardiographie ou d'hémodynamique

Echocardiographie en réanimation

Qui fait une échographie avant de remplir ?

Outils d'évaluation de la volémie :

Place de l'échocardiographie en pratique

Volume expansion in the first 4 days of shock: a prospective multicentre study in 19 French intensive care units

Primary cause of shock	
Severe sepsis or septic shock	333 (42.9 %)
Cardiogenic shock	54 (6.9 %)
Haemorrhagic shock	36 (4.6 %)
Other shock	354 (45.6 %)
Haemodynamic tools used during the period of shock (during at least one fluid bolus)	
Cardiac output monitoring	69 (8.9 %)
Central venous pressure measurement	131 (16.9 %)
Echography	56 (7.2 %)
Functional predictive indices of fluid responsiveness	134 (17.2 %)

Boulain et al Intensive Care Med 2015

Outils d'évaluation de la volémie :
Place de l'échocardiographie en pratique

Fluid challenges in intensive care: the FENICE study

A global inception cohort study 2213 patients

Maurizio Cecconi
Christoph Hofer
Jean-Louis Teboul
Ville Pettila
Erika Wilkman
Zsolt Molnar
Giorgio Della Rocca
Cesar Aldecoa
Antonio Artigas
Sameer Jog
Michael Sander
Claudia Spies
Jean-Yves Lefrant
Daniel De Backer

Hemodynamic variable used to predict fluid responsiveness	*n*	% Of category	% All
No variable used	945		42.7 [40.6–44.8]
Any variable used	1268		57.3 [55.2–59.4]
Static	785		35.5 [33.5–37.5]
CVP	572	89.9 [87.8–92.0]	25.8 [24.0–27.6]
PAOP	31	4.9 [3.4–6.4]	1.4 [0.9–1.9]
GEDVI	33	5.2 [3.6–6.8]	1.5 [1.0–2.0]
Other	149	23.4 [20.4–26.4]	6.7 [5.7–7.8]
Dynamic	483		21.9 [20.2–23.6]
PPV	88	18.2 [14.8–21.6]	4.0 [3.2–4.8]
SVV	88	18.2 [14.8–21.6]	4.0 [3.2–4.8]
PPV + SVV	24	5.0 [3.1–6.9]	1.1 [0.7–1.5]
PLR	238	49.3 [44.8–53.8]	10.7 [9.4–12.0]
Echo variables	45	9.3 [6.7–11.9]	2.0 [1.4–2.6]

Cecconi et al Intensive Care Med 2015

Outils d'évaluation de la volémie :
La clinique en difficulté…

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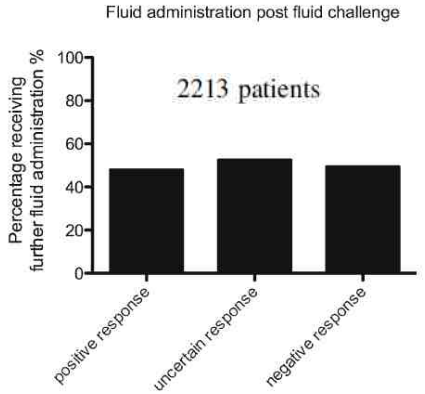
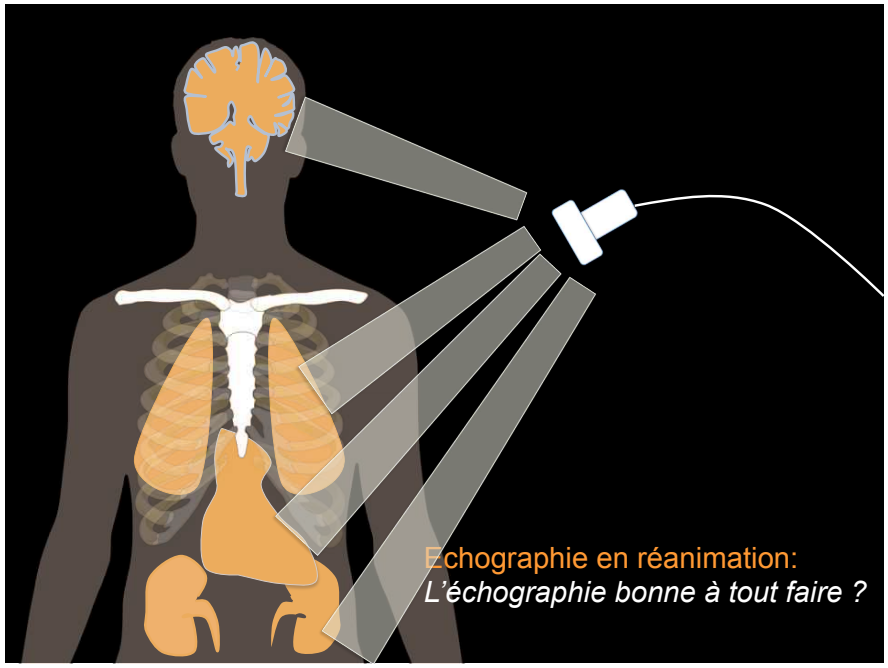


Cecconi et al Intensive Care Med 2015



Echographie en réanimation :
… Utile, peu cher et pertinent : EchoDay Study

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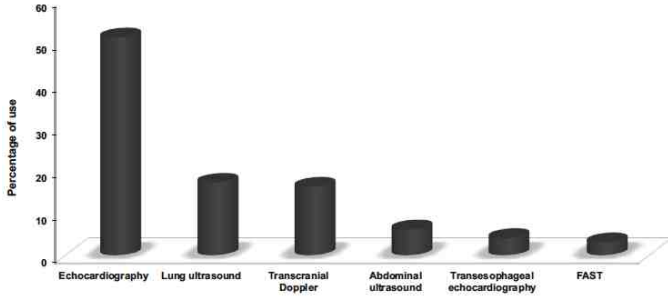
Point-of-care ultrasound in intensive care units: assessment of 1073 procedures in a multicentric, prospective, observational study



Intensive Care Med 2015

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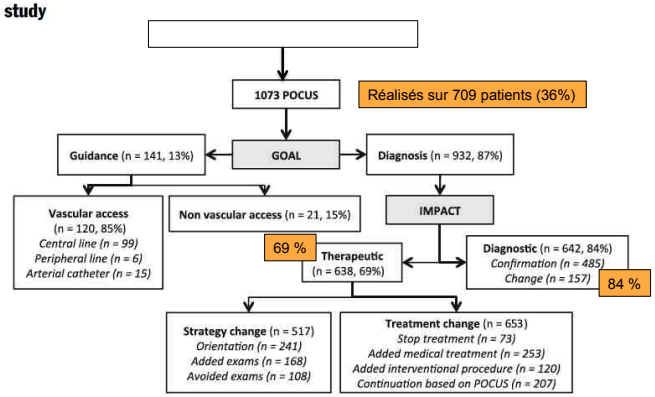

Intensive Care Med 2015

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Table 2 Interventions associated with point-of-care ultrasound performance

Intervention	$n = 373$ (%)
Hemodynamics	
Fluid bolus	115 (31)
Fluid depletion	80 (21)
Catecholamines	43 (12)
Pulmonary artery hypertension treatment	11 (2.9)
Invasive procedures	
Surgery/interventional radiology	13 (3.4)
Chest tube insertion	48 (13)
Medical treatments	
Antibiotics	10 (2.6)
Sedation	6 (1.6)
Mechanical ventilation setting	9 (2.4)
Anticoagulation	7 (1.8)
Others (miscellaneous)	31 (8.3)

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Table 3 Factors associated with diagnostic and therapeutic impacts

Variable	Univariate analysis			Multivariate analysis	
	Yes n (%)	No n (%)	p	OR (95 % CI)	p
Diagnostic impact					
US certified	464 (86)	178 (78)	0.005	2.0 (1.2–3.1)	0.002
Disinfection protocol	311 (90)	312 (80)	<0.001	2.4 (1.5–3.7)	0.004
Shock	293 (88)	337 (80)	0.05	1.5 (1.0–2.4)	0.01
Management algorithm	136 (75)	487 (87)	<0.001	0.4 (0.3–0.7)	<0.001
Pediatric patient	66 (71)	560 (86)	<0.001		
Adult patient	560 (86)	66 (71)	<0.001		
Emergency US	312 (87)	318 (80)	0.02		
PaO_2/FiO_2 <300 mmHg	268 (86)	354 (82)	0.1		
Therapeutic impact					
Operator: intensivist	579 (71)	55 (55)	0.04	1.7 (1.0–2.9)	0.002
Daily practice of US	509 (71)	124 (61)	0.001	1.8 (1.2–2.7)	0.01
TTE	349 (75)	284 (63)	0.001	1.7 (1.2–2.3)	<0.001
Emergency US	319 (75)	312 (61)	<0.001	2.6 (1.9–3.6)	<0.001
University hospital	430 (65)	180 (79)	0.01	0.6 (0.4–0.9)	<0.001
Pediatric patient	70 (52)	550 (72)	<0.001	0.4 (0.3–0.7)	<0.001
US certified	528 (71)	110 (62)	<0.001		
Ward US	166 (75)	457 (67)	0.03		
Shock	287 (73)	342 (66)	0.03		

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Echographie en réanimation :
… Utile, peu cher et pertinent

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Point-of-care ultrasound in intensive care units: assessment of 1073 procedures in a multicentric, prospective, observational study

7.5 examens / j / réanimation

Un appareil = 7 à 10 ans

Un appareil = 30 à 60 000 euros

- Un examen = 2 € hors maintenance
- Dosage du BNP = 8.64 € au CHU Nîmes en 2015
- Total BNP CHU Nîmes 2015 = 70834 €

Intensive Care Med 2015

Echocardiographie en réanimation

Quel cursus ?

Echocardiographie en réanimation : proposition d'un score de compétence

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

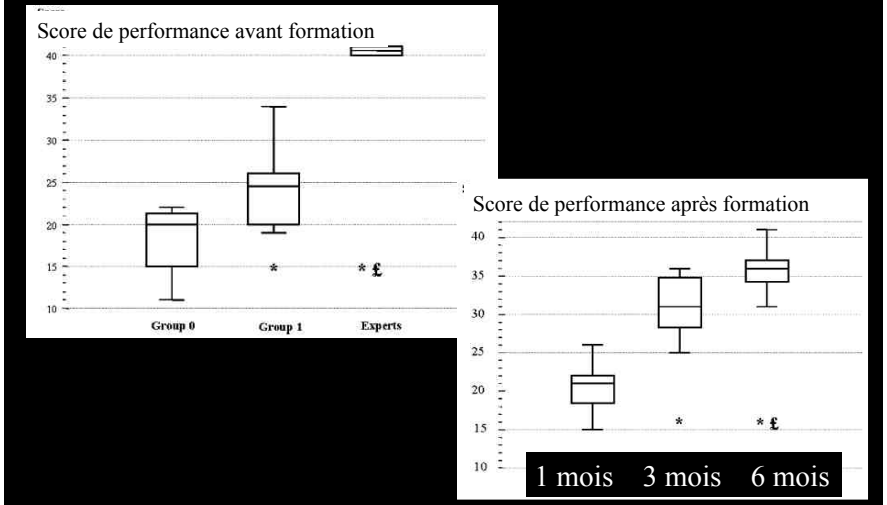
Table 1 Four-part skills assessment scoring system

Qualitative data collection				Score
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*



Charron et al Intensive Care Med 2007

Echocardiographie en réanimation : *durée d'acquisition des compétences*

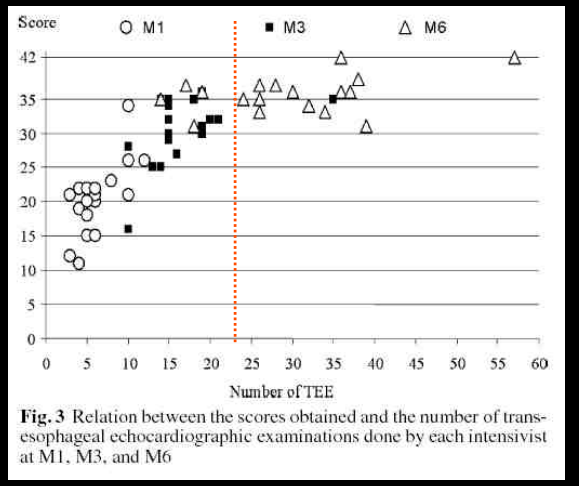


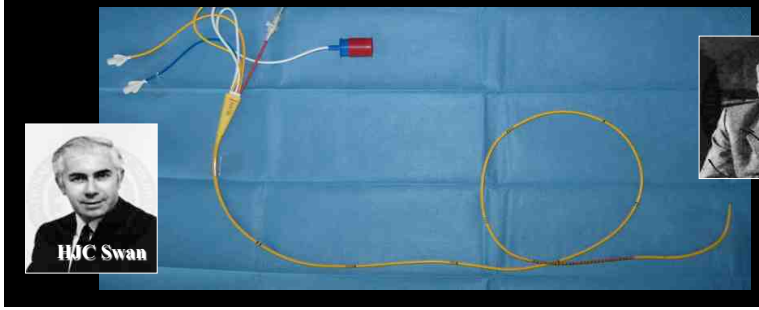
Fig. 3 Relation between the scores obtained and the number of transesophageal echocardiographic examinations done by each intensivist at M1, M3, and M6

Charron et al Intensive Care Med 2007

Echocardiographie en réanimation

Pourquoi un tel succès ?

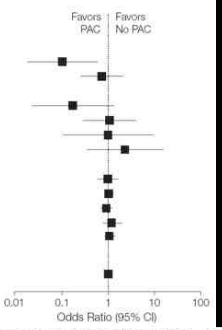
Le moniteur hémodynamique idéal :



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. of Deaths/ Total No. of Patients: 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)



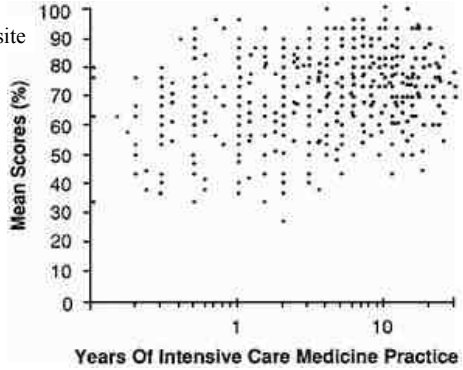
CI indicates confidence inter
trial. *P* for heterogeneity = .3

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

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

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

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

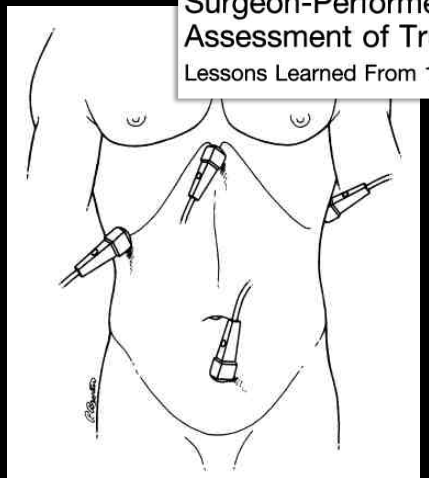


Figure 1. Transducer positions for FAST: (1) pericardial area, (2) right and (3) left upper quadrants, and (4) pelvis.

Focus
Assessment
for the
Sonographic
Examination
of the
Trauma patient

Rozycki et al Ann Surg 1998

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

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

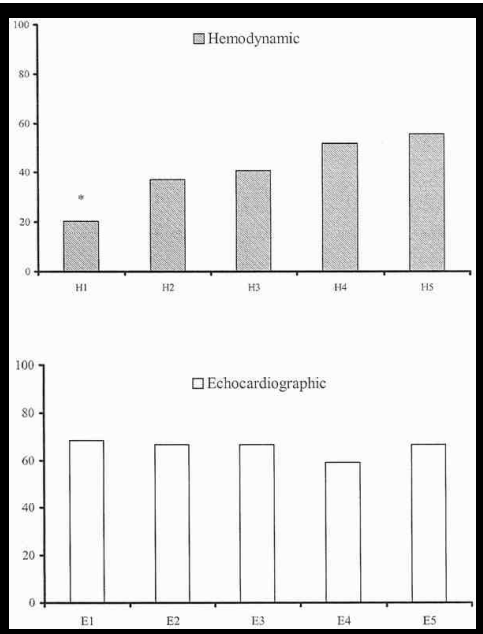
Impact of echocardiography on patient management in the intensive care unit: an audit of district general hospital practice

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

Echographie en réanimation :

Réduction globale des examens d'imagerie sans aggraver le pronostic

The Effect of Point-of-Care Ultrasonography on Imaging Studies in the Medical ICU. A Comparative Study

TABLE 1] Patient Group Characteristics

Characteristic	Réa sans écho (n = 294)	Réa avec écho (n = 328)	*P* Value
Age, y	65.5 ± 17.31	64.6 ± 18.61	NS
Male (female) sex	147 (147)	177 (151)	NS
Length of stay, d	3.59 ± 3.10	3.00 ± 3.00	NS
CCI	5	5.5	< .0001
Predicted mortality based on CCI at 1 y, %	11.5	12.65	...

TABLE 2] Number of Studies per Patient

Study	Réa sans écho (n = 294)	Réa avec écho (n = 328)	*P* Value
Chest radiograph	3.75 ± 4.6 (1,102)	0.82 ± 1.85 (269)	< .0001
Chest CT scan	0.10 ± 0.31 (29)	0.04 ± 0.20 (14)	.0007
Abdomen/pelvis CT scan	0.17 ± 0.44 (49)	0.05 ± 0.24 (16)	< .0001
Radiology service-performed DVT	0.20 ± 0.47 (58)	0.02 ± 0.14 (7)	< .0001
Cardiology service-performed TTE	0.18 ± 0.40 (54)	0.07 ± 0.26 (22)	< .0001

Oks et al Chest 2014

Echographie en réanimation : recommandations

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

Compétences échographiques en réanimation : échocardiographie

Table 7—*Competence in Basic CCE: Required Cognitive Skills in Recognition of Clinical Syndromes*

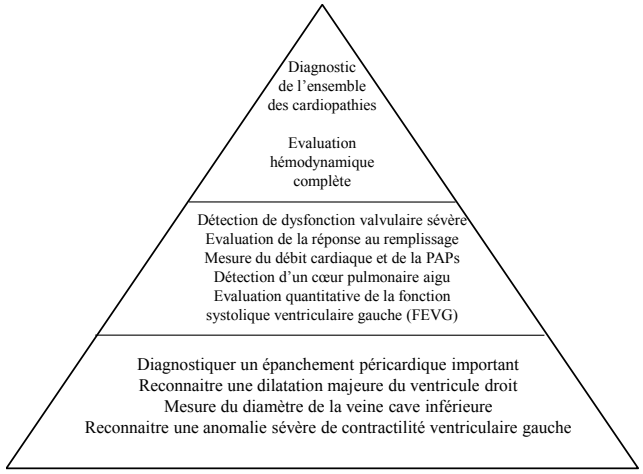
Clinical Syndromes	Echocardiographic Findings
Severe hypovolemia	Small, hyperdynamic ventricles Small IVC with wide respiratory variations
LV failure	Global LV systolic dysfunction Heterogeneous contractility pattern suggestive of myocardial ischemia LV cavity dilatation suggestive of chronic cardiac disease
RV failure	Acute cor pulmonale: RV dilatation and paradoxical septal motion* Isolated RV dilatation suggestive of RV infarct Associated findings: dilated, noncollapsible IVC
Tamponade	Pericardial effusion (regardless of size)† Right atrial/RV diastolic collapse Associated findings: dilated, noncollapsible IVC
Acute massive left-sided valvular regurgitation	Normal LV cavity size (acute valvulopathy) Normal/hyperdynamic LV systolic function (LV volume overload) Massive color Doppler regurgitant flow‡
Circulatory arrest	
During resuscitation	Tamponade or acute cor pulmonale (from massive pulmonary embolism) LV systolic function (cardiac standstill vs severely depressed vs hyperdynamic) Global LV systolic dysfunction
After successful resuscitation	Heterogeneous contractility pattern suggestive of myocardial ischemia

Table 6—*Competence in Basic Critical Care Echocardiography: Required Cognitive Skills in Image Interpretation*

Echocardiographic patterns
Global LV size and systolic function
Homogeneous/heterogeneous LV contraction pattern
Global RV size and systolic function
Assessment for pericardial fluid/tamponade
IVC size and respiratory variation
Basic color Doppler assessment for severe valvular regurgitation

Mayo et al Chest 2009

Echocardiographie en réanimation : *pyramide des compétences*



Cholley et al Intensive Care Med 2005

Echocardiographie en réanimation

Evaluation de la fonction systolique VG

Dysfonction VG en réanimation :

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

Table 4 Reproducibility of measurements

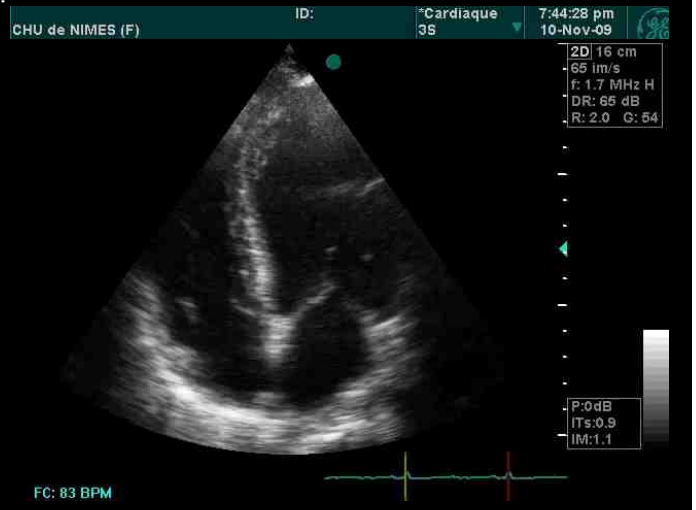
	Visual	Simpson	TDIs	AVPDm	LVOT VTI
Intraobserver	6.8	10.6	8.2	4.4	3.1
Interobserver	9.9	8.2	7.2	5.3	4.8

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

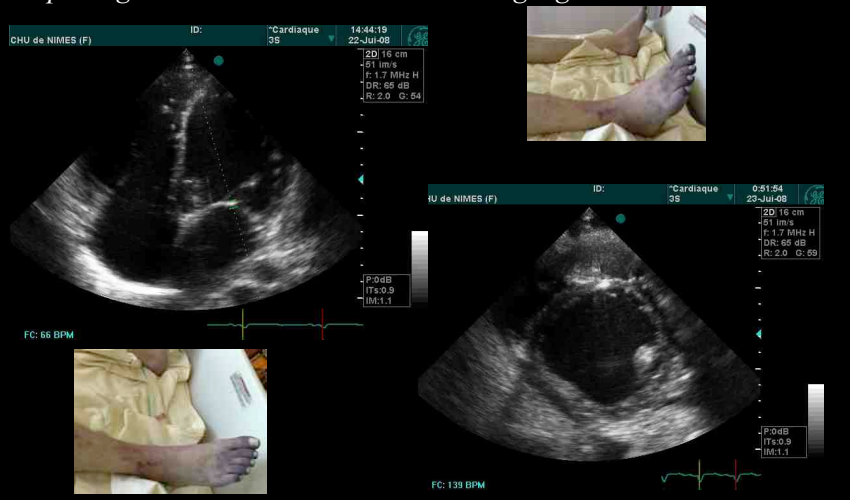
Fonction systolique VG

Ici FEVG = ?

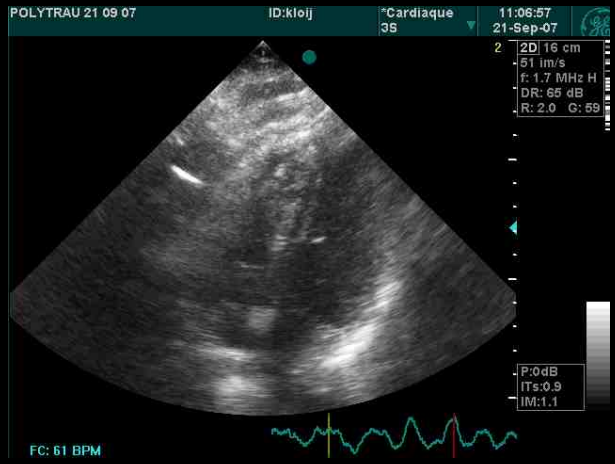


Fonction systolique VG

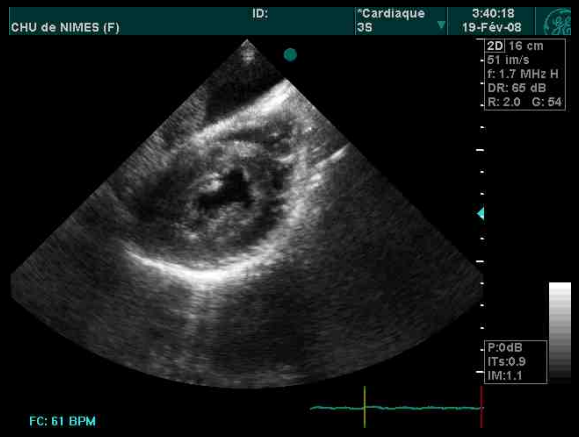
Remplissage 4000 ml et noradrénaline 2 mcg/Kg/min



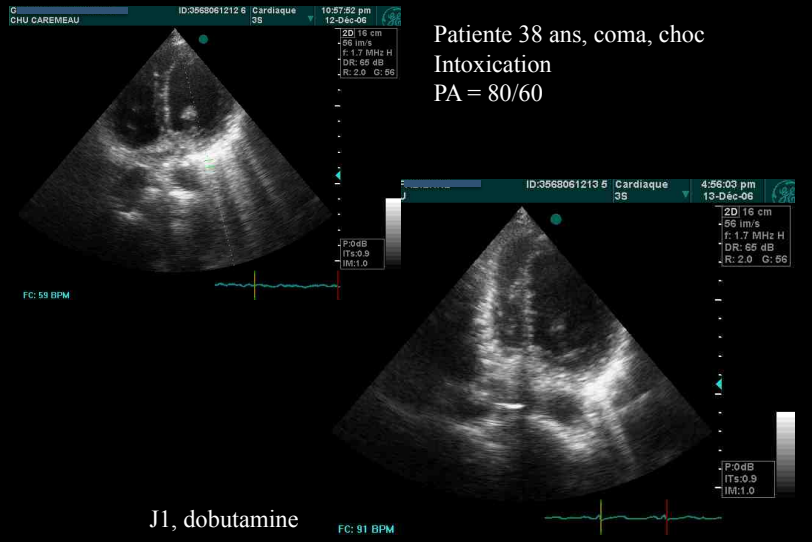
Fonction ventriculaire gauche…



Fonction ventriculaire gauche…



Fonction systolique VG en réa :



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

J1, dobutamine

Dysfonction VG en réa :

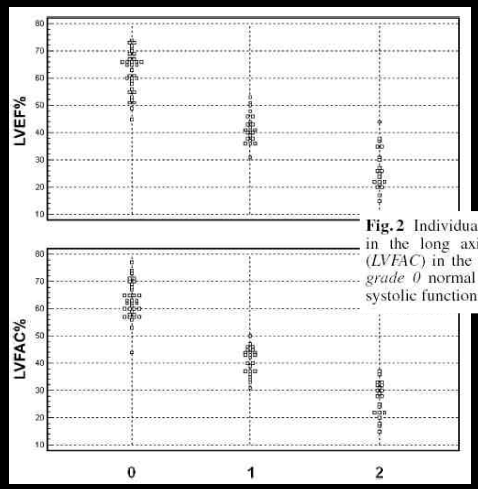


Fig. 2 Individual values of left ventricular ejection fraction (*LVEF*) in the long axis (*above*) and left ventricular area contraction (*LVFAC*) in the short axis (*below*) in the three qualitative groups: *grade 0* normal systolic function; *grade 1* moderately depressed systolic function; *grade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

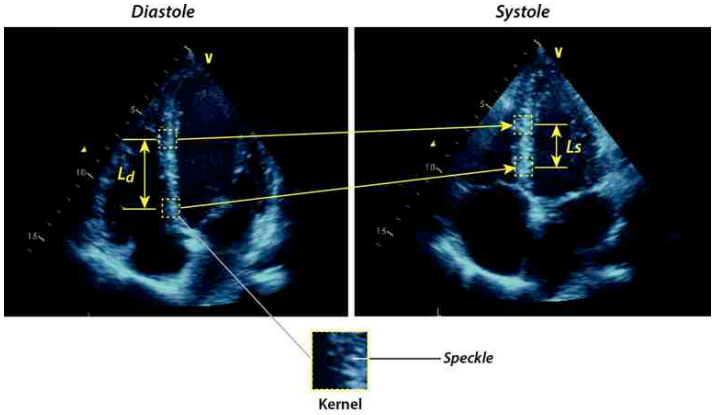
Vieillard Baron et al Intensive Care Med 2006

Echocardiographie en réanimation

2D strain en anesthésie réanimation

Nouveautés en échographie en réanimation :

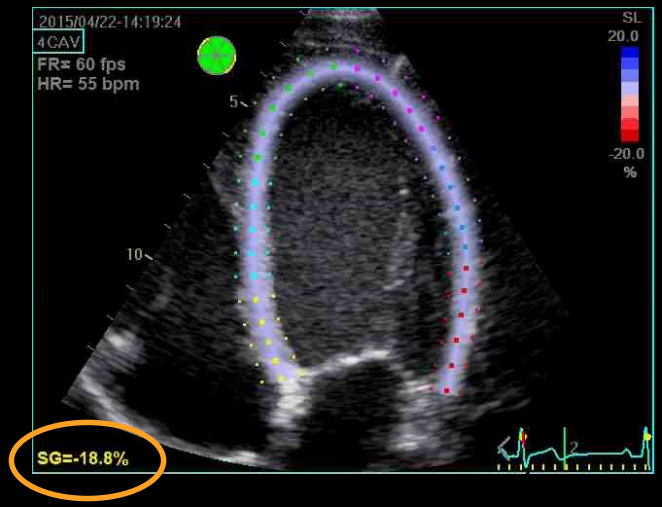
2D Strain - speckle tracking : echo de suivi des marqueurs acoustiques



$$\text{Systolic strain} = {}^{(L_S - L_d)}/_{L_d} \times 100\%$$

Vignon, Huang. Intensive Care Med 2015

Valeur normale du strain global



Valeurs normales du *strain* et du *strain rate* longitudinal

Strain :
un marqueur très robuste de contractilité régionale et globale
Normale = - 18 %

	Femmes		Hommes	
	Strain télésystolique (%)	Pic systolique de SR	Strain télésystolique (%)	Pic systolique de SR
< 40 ans	-17,9 % (2,1)	-1,09s^{-1} (0,12)	-16,8 % (2,0)	-1,06s^{-1} (0,13)
40-60 ans	-17,6 % (2,1)	-1,06s^{-1} (0,13)	-18,8 % (2,2)	-1,01s^{-1} (0,12)
> 60 ans	-15,9 % (2,4)	-0,97s^{-1} (0,14)	-15,5 % (2,4)	-0.,97s^{-1} (0,14)
Total	-17,4 % (2,3)	-1,05s^{-1} (0,13)	-15,9 % (2,3)	-1,01s^{-1} (0,13)

Dalen et al Eur Jechocardiogr 2010

Strain longitudinal global :

Variabilité intra-observateurs du 2D strain = 3,6% à 5,3 %

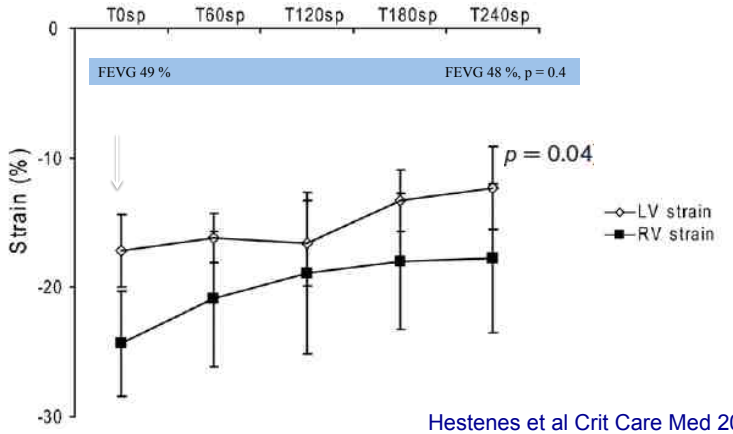
Variabilité inter-observateurs du 2D strain = 7 % à 11,8 %

Variabilité Simpson > 10%

Bergenzaum et al Crit Care 2011
Perk et al JASE 2007

2D Strain en réanimation :
… Etude animale

Advantages of Strain Echocardiography in Assessment of Myocardial Function in Severe Sepsis: An Experimental Study*

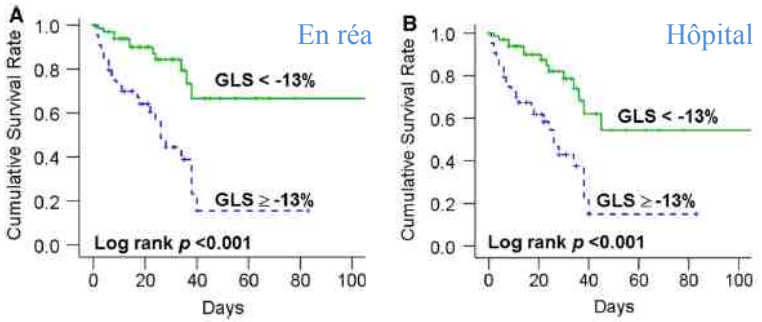


Hestenes et al Crit Care Med 2014

2D Strain en réanimation :
… Facteur pronostique au cours du sepsis (n = 111)

Wei-Ting Chang
Wen-Huang Lee
Wei-Ting Lee
Po-Sheng Chen
Yu-Ru Su
Ping-Yen Liu
Yen-Wen Liu
Wei-Chuan Tsai

Left ventricular global longitudinal strain is independently associated with mortality in septic shock patients



Chang et al Intensive Care Med 2015

2D Strain en réanimation :
… Facteur pronostique au cours du sepsis (n = 111)

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Left ventricular global longitudinal strain is independently associated with mortality in septic shock patients

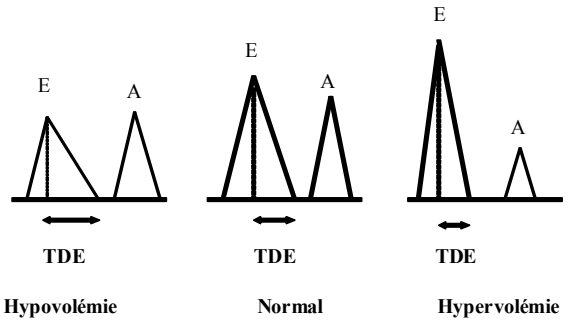
Table 3 Univariable and multivariable predictors of ICU mortality

	Univariable		Multivariable			
			Model 1		Model 2	
	HR (95 % CI)	*p*	HR (95 % CI)	*p*	HR (95 % CI)	*p*
Age	1.00 (0.98–1.02)	0.75	–	–	–	–
Male gender	0.66 (0.32–1.35)	0.26	–	–	–	–
Hypertension	0.89 (0.41–1.93)	0.76	–	–	–	–
Alcoholism	1.12 (0.48–2.65)	0.79	–	–	–	–
APACHE II score (24 h)	1.05 (1.01–1.10)	0.03	1.06 (1.02–1.10)	0.01	1.06 (1.02–1.11)	0.006
Heart rate	1.01 (0.99–1.03)	0.28	–	–	–	–
Reduced GLS (GLS ≥ −13 %)	4.34 (2.10–8.92)	<0.001	4.21 (2.02–8.80)	<0.001	–	–
GLS	1.15 (1.07–1.23)	<0.001	–	–	1.14 (1.06–1.23)	<0.001

Chang et al Intensive Care Med 2015

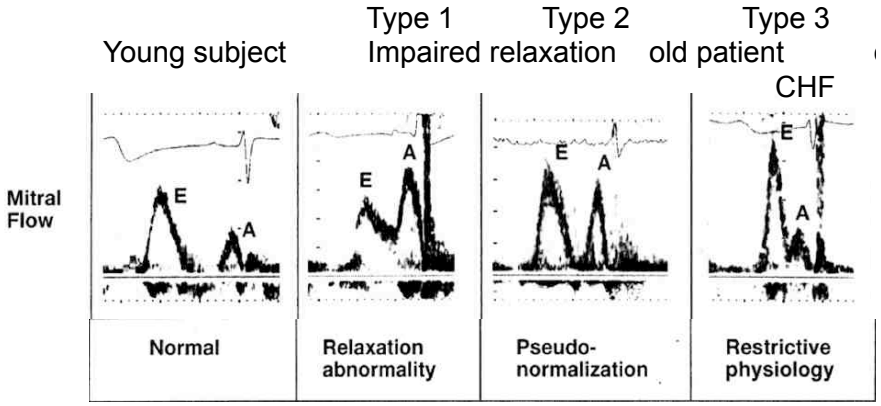
Echocardiographie en réanimation
Evaluation de la fonction diastolique VG
= évaluation de la PTDVG

Evaluation statique de la PTDVG:
La fonction diastolique vue par les réanimateurs…



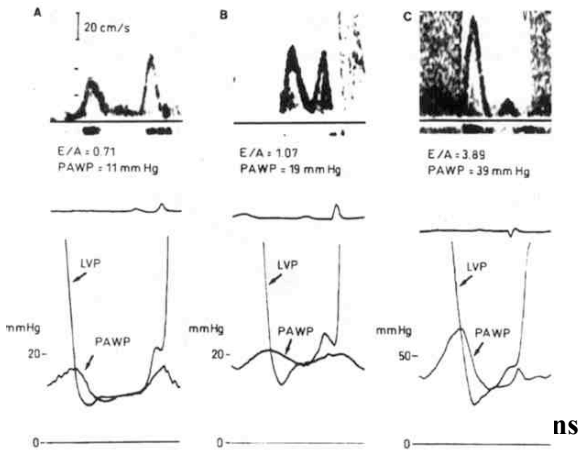
Vanoverschelde et al Am J Cardiol 1995

Evaluation statique de la PTDVG:
Pressions de remplissage = fonction diastolique



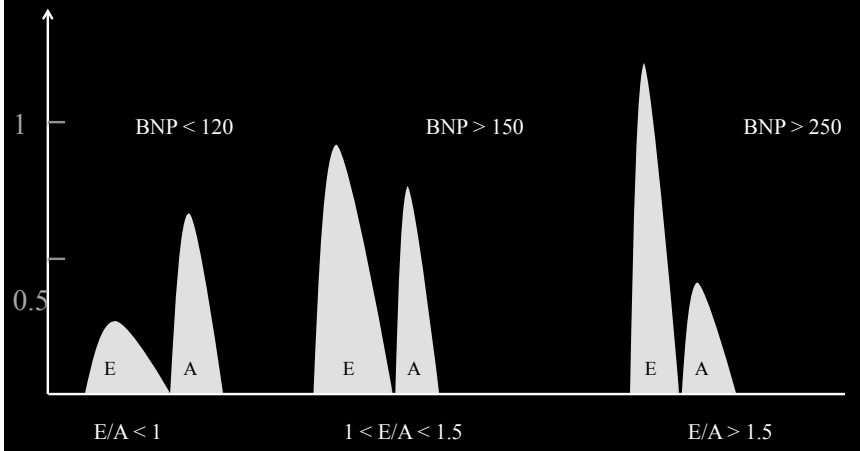
Aurigemma et al NEJM 2004
Sagie et al. JASE 1993

Evaluation statique de la PTDVG:
Le profil mitral est corrélé à la PTDVG



Vanoverschelde et al Am J Cardiol 1995

BNP, échocardiographie et fonction diastolique (= PTDVG) :
Evolution du flux mitral corrélée au BNP – donc BNP inutile !!!



Lubien et al Circulation 2002

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

- Normal E wave velocity = 0,7 – 1 m/s

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

incremental 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

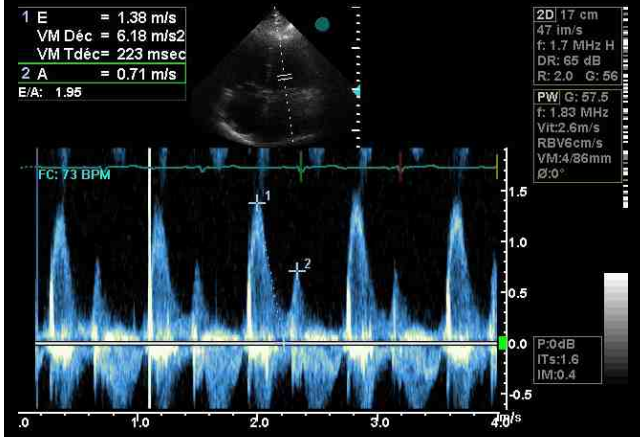
Vitesse de l'onde E :
*HYPOVOLEMIE **si < 0.75 m/s ??***

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

Evaluation statique de la PTDVG:
Rapposrt E/A très positif = pressions hautes



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

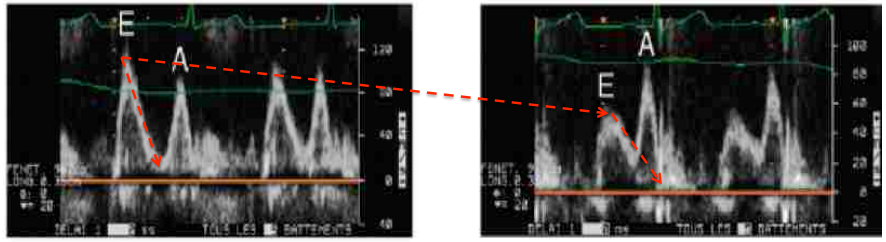
(VPP = 100 %)

Chez sujet critique
Pas sujet sain

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

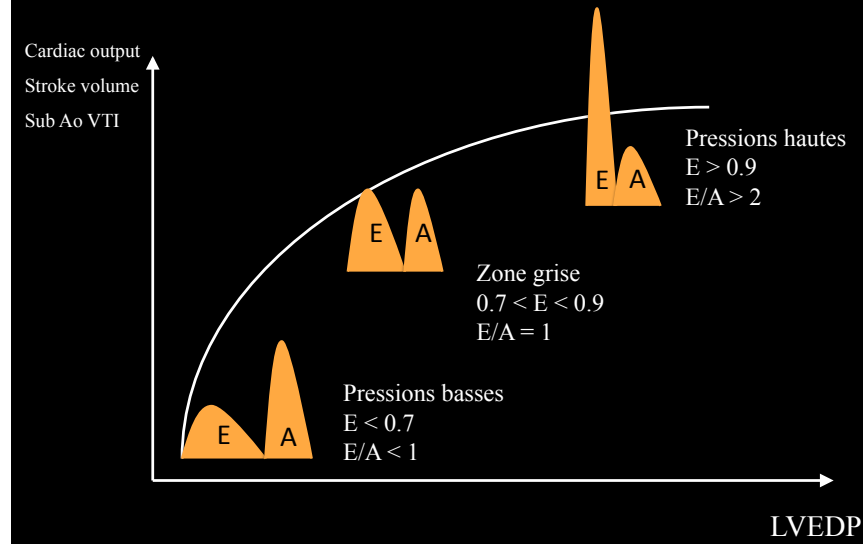
Evaluation statique de la PTDVG:
L'onde E varie avec la volémie

Before dialysis ⟵ *3000 ml fluid removal* ⟶ After dialysis



Vignon et al Crit Care 2007

Evolution du profil mitral avec la volémie



Doppler mitral :
... DEUX importantes limitations

Chez un sujet jeune et sportif :

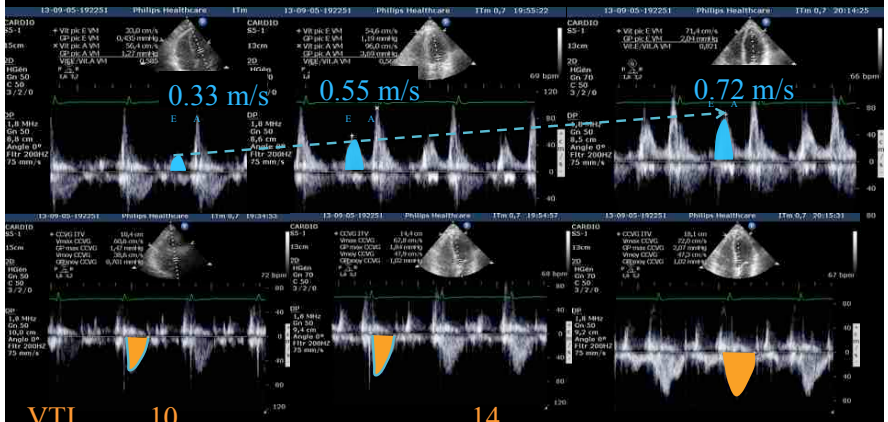
- L'onde E peut être > 1 m/s de façon physiologique
- E/A peut être > 2 de façon physiologique!

=> Dans ce cas, regarder les autres indices

Echocardiographie en réanimation
Coupler pressions et débit (ou VES)

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

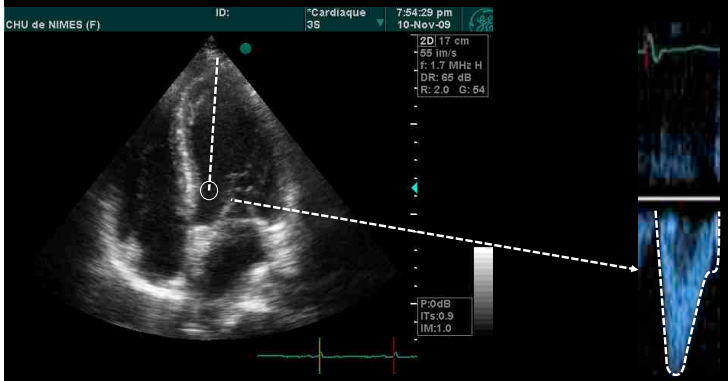
Femme de 72 ans, choc, péritonite



VTI 10 14

remplissage 500 mL 1000 mL

Coupler le profil mitral au débit cardiaque
...l'ITV ss Aortique suffit



ITV ssAo : Nale = 14 à 20

Hémodynamique et échographie :
Les 3 profils fondamentaux

- Bon VG, Pressions basses (E < 0.7) + débit bas (ITV < 14)

  = hypovolémie => remplissage

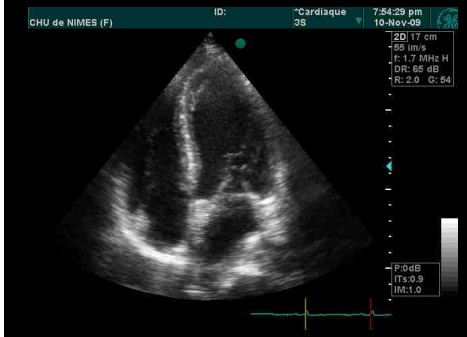
- Pressions hautes (E > 0.9) et débit bas (ITV < 14)

  = insuffisance cardiaque => diurétiques, inotropes

- Bon VG, pressions hautes ou basses et débit haut (ITV > 20)

  = Vasoplégie => noradrénaline

Remplissage ou vasopresseurs
...raisonnement pratique?



+ Pression pulsée > 40 mmHg

+ diastolique basse

et / ou

ITV sous aortique > 20

= vasoplégie probable !

Avis personnel

Echographie en réanimation

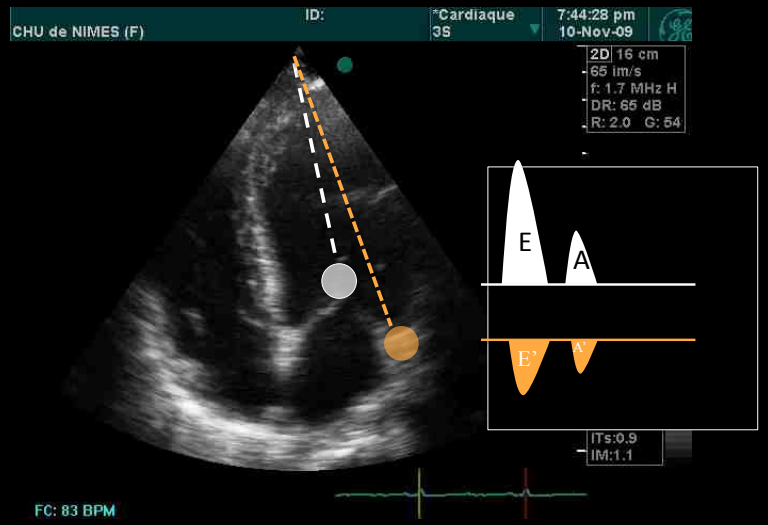
Prédire la réponse à l'expansion volémique

...and surrogates

Echographie en réanimation

Etre au clair avec le rapport E/E'

Rapport E / E’



Rapport E/E’

E = Charge x Compliance

E’ = Compliance

Théoriquement, l’onde E’ est précharge indépendante

Rapport E/E’

$$\frac{E}{E'} = \frac{\text{Charge x Compliance}}{\text{Compliance}}$$

Rapport E/E’

$$\frac{E}{E'} = \frac{\text{Charge x Compliance}}{\text{Compliance}}$$

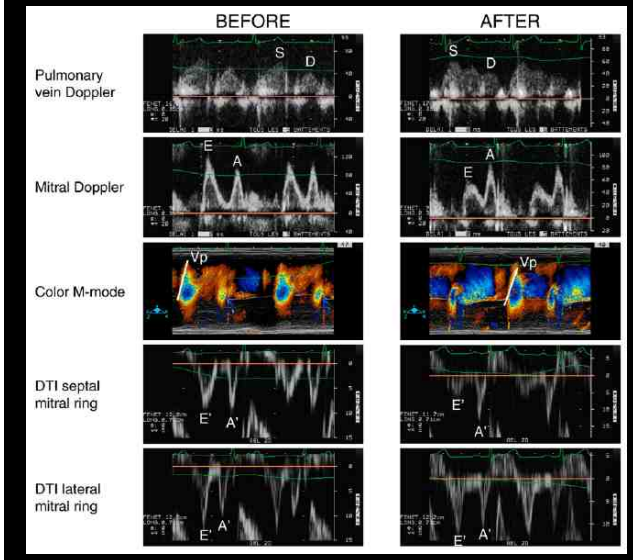
Rapport E/E’

Pour les cardiologues : E/E’ > 10 = pressions hautes

Pour les cardiologues : E/E’ < 10 = pressions basses

En réanimation : zone grise de 6 à 11

TDI en réanimation : à l’anneau latéral ?



Vignon et al Crit Care 2007

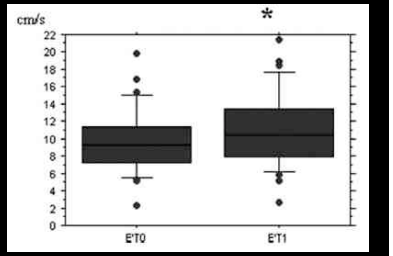
TDI en réanimation

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 (cm²)	17.2 ± 5.4	18.5 ± 5.5	<0.05

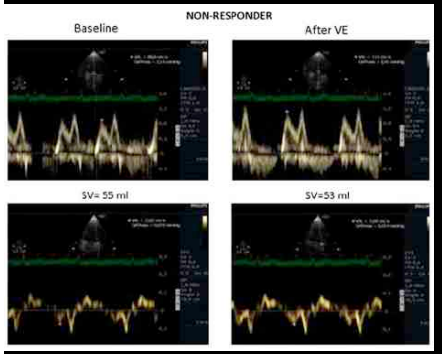


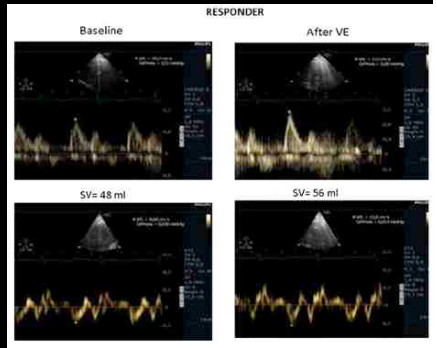
Quintard et al JCU 2011

TDI en réanimation

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

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

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

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

TDI en réanimation

Baseline haemodynamic parameters	Responders ($n = 59$)	Non responders ($n = 24$)	p
HR (bpm)	100 ± 18	96 ± 21	0.32
SAP (mmHg)	99 ± 20	100 ± 20	0.36
DAP (mmHg)	55 ± 12	55 ± 13	0.33
MAP (mmHg)	69 ± 13	70 ± 20	0.84
CVP (mmHg)	8.8 ± 6.6	11.5 ± 4.0	0.30
Stroke volume (ml)	52 ± 16	67 ± 22	0.006
Lactates (mmol/l)	3.0 ± 1.8	3.4 ± 2.3	0.40
Cardiac output (l/min)	5.2 ± 1.6	6.3 ± 2.3	0.04
LVEDA (cm^2)	28 ± 6	28 ± 10	0.64
E wave (m/s)	0.70 ± 0.20	0.76 ± 0.22	0.23
A wave (m/s)	0.80 ± 0.21	0.80 ± 0.21	0.95
E/A ratio	0.92 ± 0.41	0.98 ± 0.35	0.58
EDT (ms)	248 ± 107	226 ± 108	0.34
E′ wave (m/s)	0.12 ± 0.04	0.12 ± 0.05	0.60
A′ wave (m/s)	0.12 ± 0.04	0.11 ± 0.04	0.31
E/E′ ratio	6.5 ± 2.2	6.9 ± 2.7	0.41
Tei index	0.78 ± 0.38	0.54 ± 0.16	0.04
EF (%)	55 ± 15	53 ± 16	0.49
S′ wave (m/s)	0.16 ± 0.04	0.15 ± 0.06	0.4

Mahjoub et al Intensive Care Med 2013

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

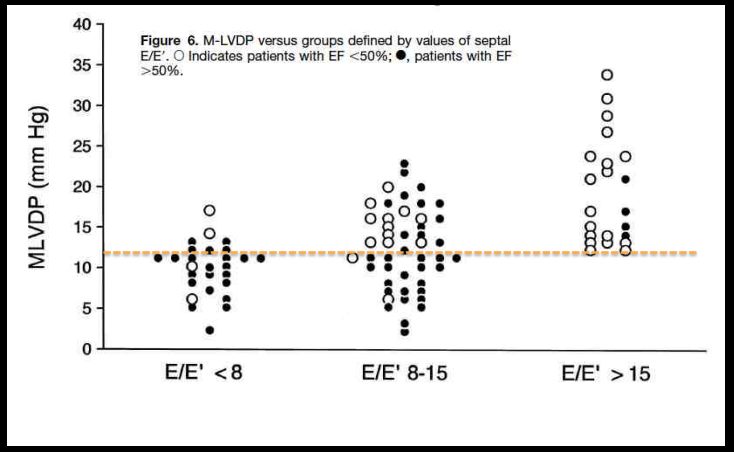
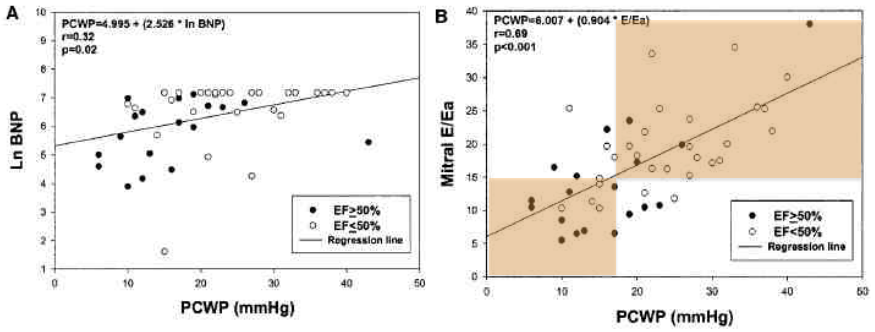


Figure 6. M-LVDP versus groups defined by values of septal E/E'. ○ Indicates patients with EF <50%; ●, patients with EF >50%.

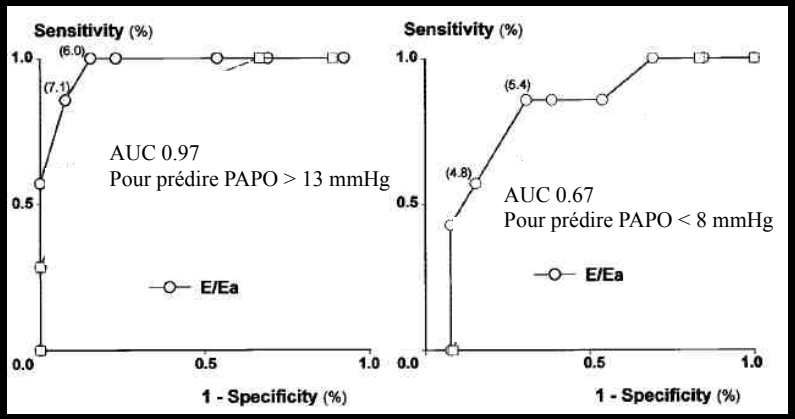
Ommen et al Circulation 2000

BNP vs échocardiographie :
Meilleure corrélation écho-Swan que écho - BNP



Dokainish et al Circulation 2004

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



Bouhemad et al Anesthesiology 2003

Rapport E/E'
… take home messages

Le rapport E/E' est inutile pour l'hypovolémie

Plus il est élevé, plus les pressions sont hautes

Cutoff sup = 11 à 15 en réanimation (pressions hautes)

Cutoff inférieur : 4 à 5 ??? (pressions basses)

Actualités en échographie

Etre au clair avec l'onde E'

Dysfonction diastolique comme marqueur de gravité :
Prendre en compte une valeur effondrée de l'onde E'

Filippo Sanfilippo
Carlos Corredor
Nick Fletcher
Giora Landesberg
Umberto Benedetto
Pierre Foex
Maurizio Cecconi

Diastolic dysfunction and mortality in septic patients: a systematic review and meta-analysis n = 636, dysf diasto = 48 %

Author/year	Population	TTE vs TEE	Age	% MV	DD cut-off	SD cut-off	Longest follow-up
Etchecopar-Chevreuil et al. [23]	35 ICU patients with septic shock	TEE within 12 h	Alive 54 ± 18, died 68 ± 14	100 %	Lateral e′ < 8.5 cm/s	LVEF < 50 %	28 days
Landesberg et al. [24]	106 ICU patients with severe sepsis and septic shock	TTE on admission or asap	Alive 56 ± 21, died 70 ± 17*	100 %	Septal e′ < 8 cm/s	LVEF < 50 %	12 months
Landesberg et al. [12]	262 ICU patients with severe sepsis and septic shock	TTE asap + day after admission	Alive 60 ± 20, died 71 ± 15*	100 %	Septal e′ < 8 cm/s	LVEF < 50 %	12 months
Mokart et al. [25]	45 ICU oncological patients with septic shock	TTE within 24 h	56 ± 13	49 %	ASE guidelines (lateral e′)	LVEF < 45 %	ICU stay
Mourad et al. [26]	72 ICU oncological patients with septic shock	TTE within 48 h[b]	58 ± 12	54 %	Lateral e′ < 8 cm/s	LVEF < 50 %	ICU stay
Pulido et al. [13]	106[a] ICU patients with severe sepsis or septic shock	TTE within 24 h	65 ± 15	N/A	ASE guidelines (septal and lateral e′)	LVEF < 50 %	12 months
Sturgess et al. [27]	21 ICU patients with septic shock	TTE within 72 h[c]	65 ± 17	76 %	ASE guidelines (septal e′)	LVEF < 55 %	Hospital stay

Sanfilippo et al Intensive Care Med 2015

Dysfonction diastolique comme marqueur de gravité :
Onde E' effondrée plus grave qu'une FEVG basse !

Filippo Sanfilippo
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Umberto Benedetto
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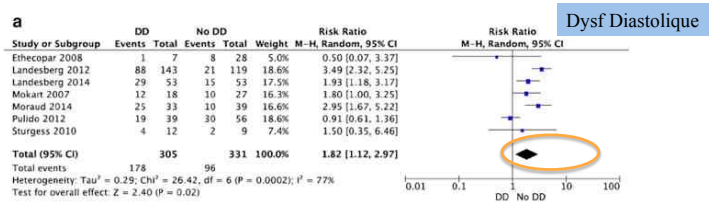
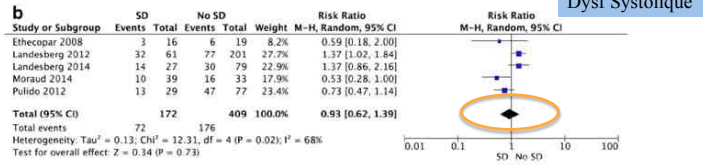
Diastolic dysfunction and mortality in septic patients: a systematic review and meta-analysis

Dysf Diastolique



Dysf Systolique



Sanfilippo et al Intensive Care Med 2015

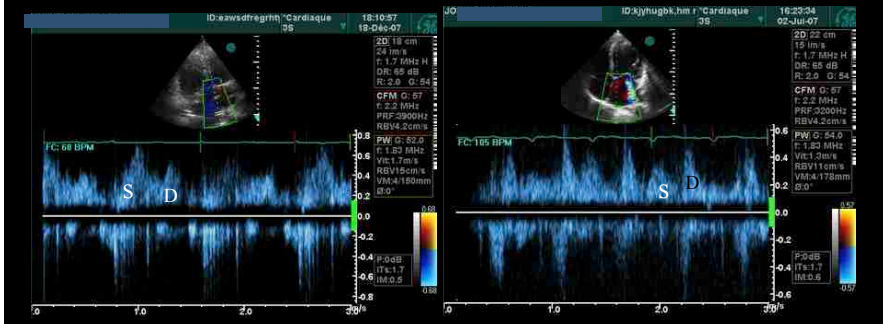
Echocardiographie en réanimation

Flux veineux pulmonaire

=> Si le flux mitral et le TDI sont non informatifs

Précharge haute : inversion du flux veineux pulmonaire

Flux veineux pulmonaire en réanimation

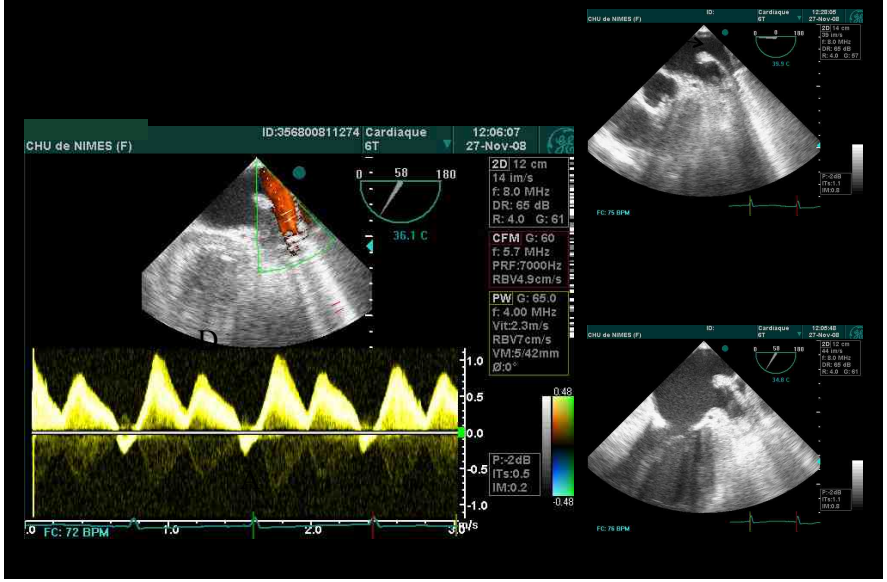


Normal

Pressions hautes

Boussuges et al Crit care Med 2002

Flux veineux pulmonaire en pratique : facile en ETO



Flux veineux pulmonaire : influence de l'âge

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 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

Hémodynamique et échographie :
Les 3 profils fondamentaux

- Bon VG, Pressions basses (E < 0.7) + débit bas (ITV < 14)

  = hypovolémie => remplissage

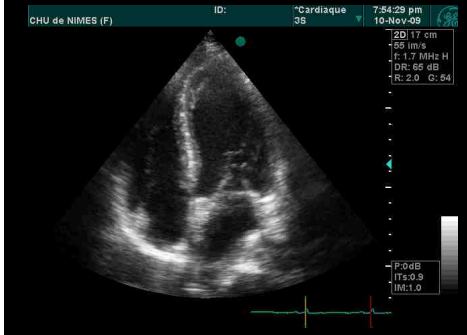
- Pressions hautes (E > 0.9) et débit bas (ITV < 14)

  = insuffisance cardiaque => diurétiques, inotropes

- Bon VG, pressions hautes ou basses et débit haut (ITV > 20)

  = Vasoplégie => noradrénaline

Remplissage ou vasopresseurs
...raisonnement pratique?



+ Pression pulsée > 40 mmHg

+ diastolique basse

et / ou

ITV sous aortique > 20

= vasoplégie probable !

Avis personnel