SFAR LE CONGRÈS
18 - 21 septembre 2013

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CHU Nîmes

Echocardiographie et gestion du remplissage vasculaire :

Une démarche en 4 points

AZUREA

Conflits d'intérêts

General Electrics
Baxter
Fresenius Kabi
B Braun
LFB
Lilly
Astellas

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

Need for a step by step approach !

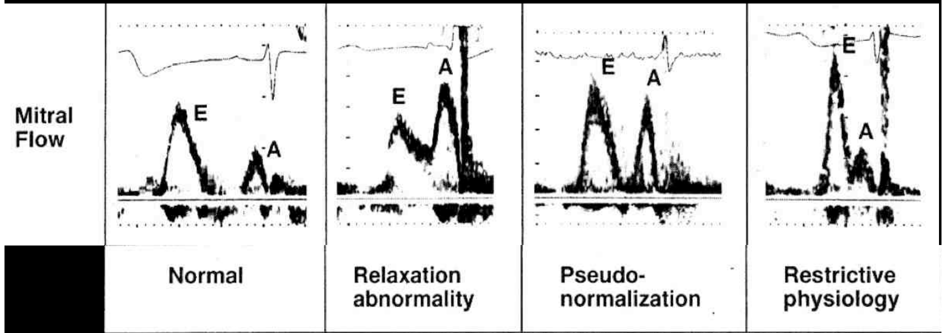
Première étape – approche statique

Evaluation de la PTDVG

Evaluation statique de la PTDVG:

Mitral Flux = fonction diastolique

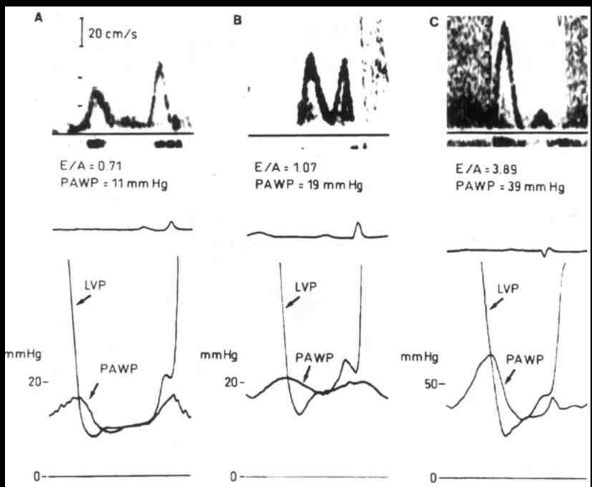
Young subject	Type 1	Type 2	Type 3
	Impaired relaxation, old patient		decompensated CHF



Aurigemma et al NEJM 2004
Sagie et al. JASE 1993

Evaluation statique de la PTDVG:

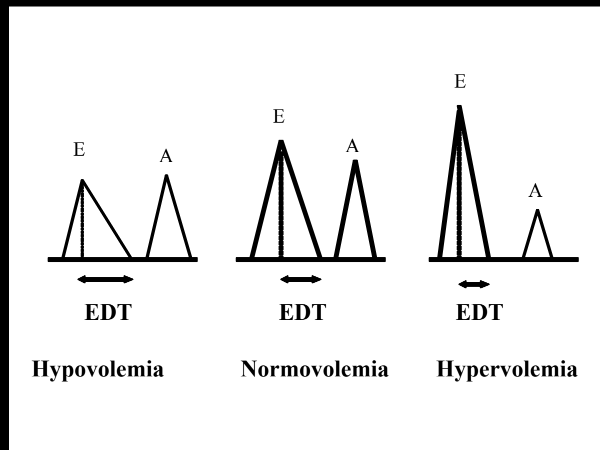
Le profil mitral est corrélé à la PTDVG



Vanoverschelde et al Am J Cardiol 1995

Evaluation statique de la PTDVG:

Au cours d'un choc ou d'une dyspnée, l'onde E varie avec la volémie

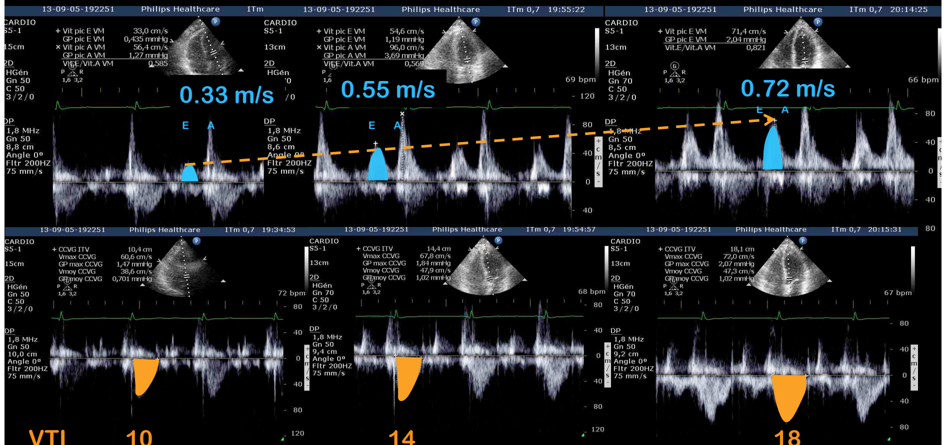


E wave velocity :
What we need to know about E wave is

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

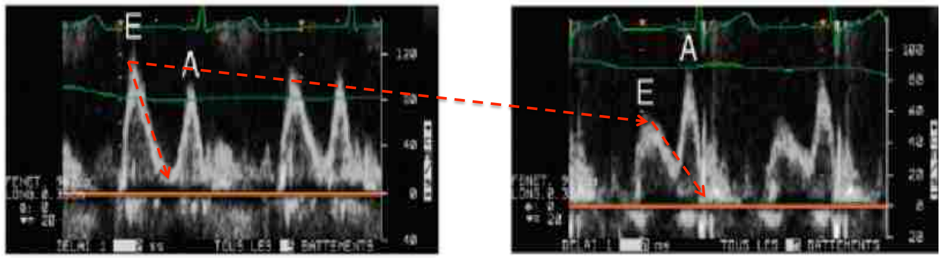
Evaluation statique de la PTDVG:
L'onde E varie avec la volémie

Femme de 72 ans, choc, péritonite



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

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

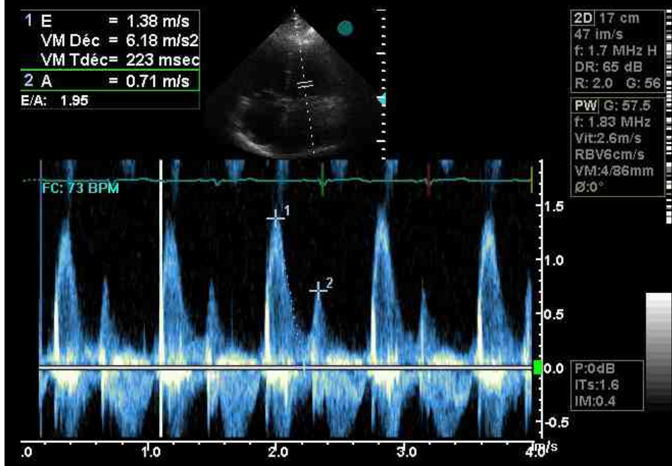
... incremental accuracy to E/Ea alone in patients with E/Ea in the gray zone. Finally, in this population, E <60 cm/sec ruled out, and E>90 cm/sec ruled in, elevated LVEDP with high negative and positive predictive values, respectively, which, in the right clinical setting, may be useful screening tools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

Rapport E/A:
Un bon marqueur de pressions hautes si > 2



E/A ratio > 2

=

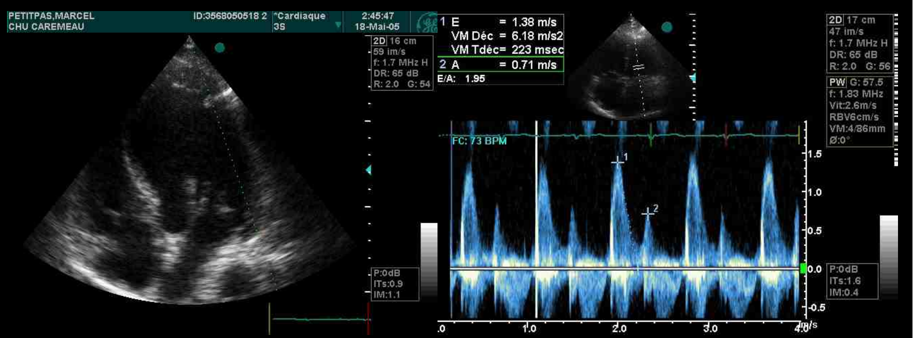
PAPO > 18 mmHg

PP value = 100 %

Boussuges et al Critical Care Med 2002

Mitral inflow pattern:
... Boosts your stethoscope performance !

A 72 year old man, Dyspnea, T° 38°5, cough, Blood pressure 130/80 mmHg
Is it only a pneumonia ?



Better clinical conditions after diuretics !

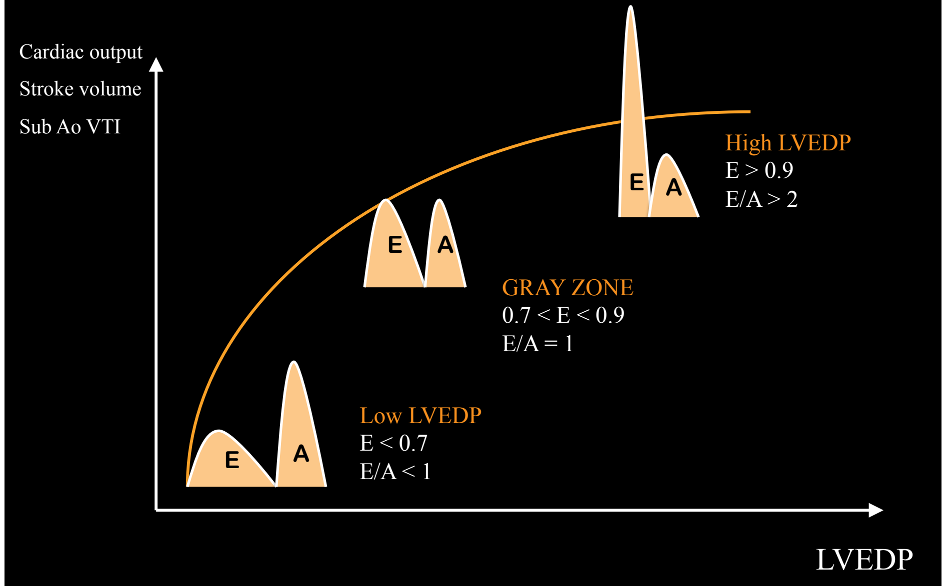
Doppler mitral :
... DEUX importantes limitations

Chez un sujet jeune et sportif :

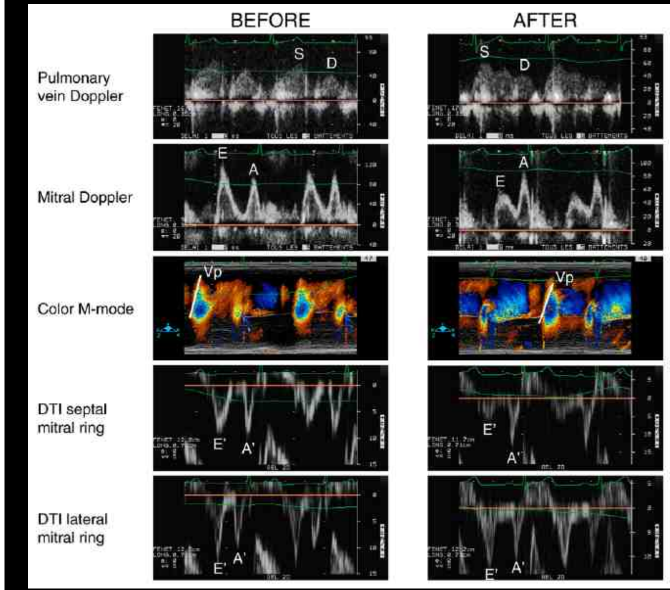
- L'onde E peut être > 1 m/s de façon physiologique
- E/A peut être > 2 de façon physiologique!

=> Dans ce cas, regarder les autres indices

Static indices, fluid responsiveness and the Frank-Starling curve



Flux mitral et dialyse : monitorage de la volémie

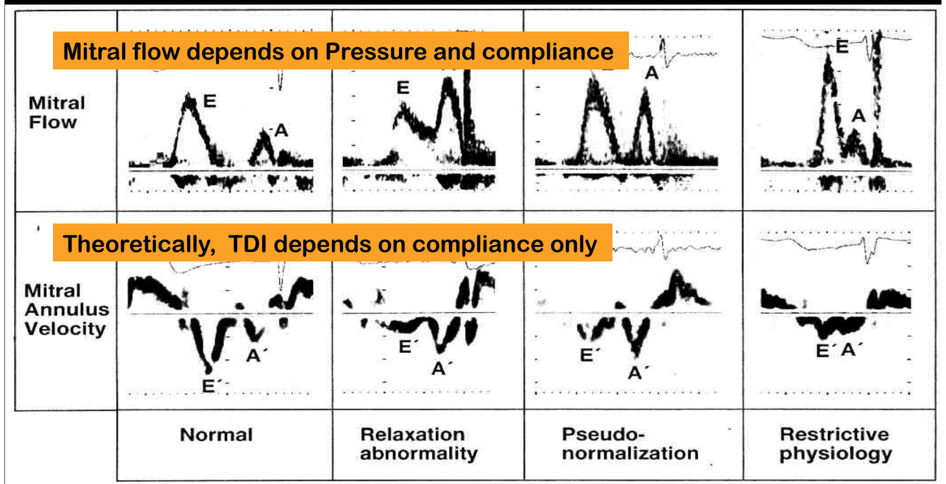


Vignon et al Crit Care 2(

Evaluation de la PTDVG par l'écho :
Le Doppler mitral en défaut

- Si l'onde E est dans la zone grise 0,7 – 0,9 m/s
- On peut regarder le rapport E/E'

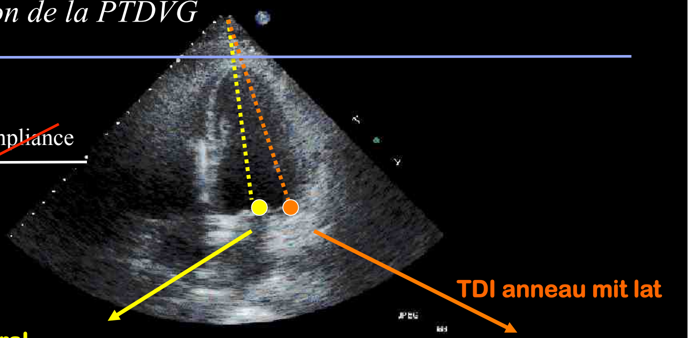
Static evaluation of LVEDP:
TDI pattern and diastolic function



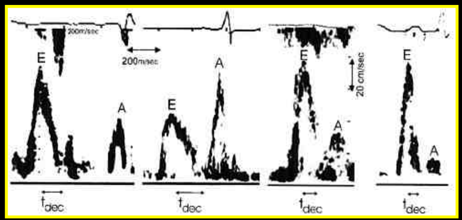
Aurigemma et al NEJM 2004
Sagie et al. JASE 1993

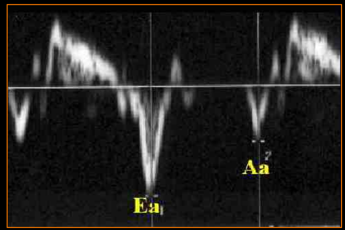
Rapport E sur E’:
… Une évaluation de la PTDVG

$$E = \text{Pression (L)} \times \text{Compliance}$$
$$E' = \text{Compliance}$$
$$E / E' = \text{Pressure (L)}$$

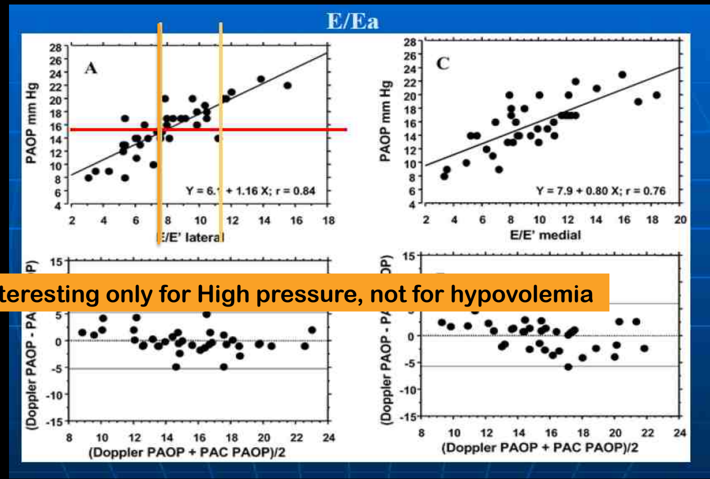


Doppler pulsé mitral



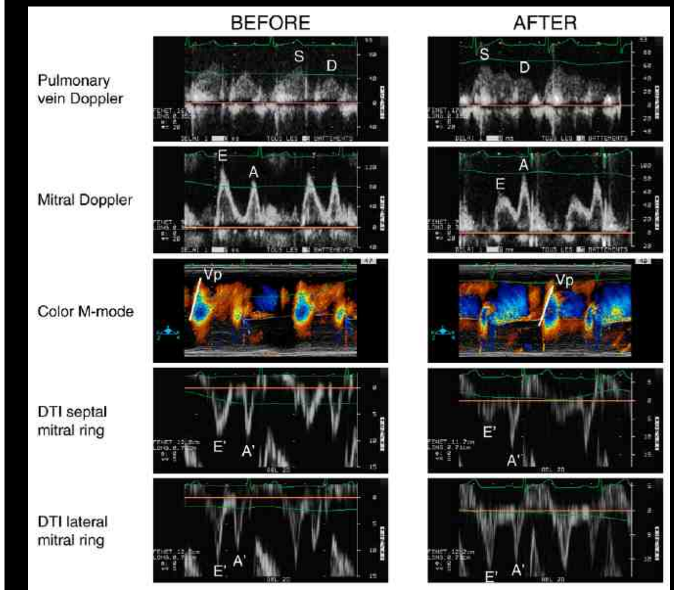


Static evaluation of LVEDP:
E/E’ in critically ill patients : gray zone 7 to 11



Combes et al Intensive Care Med 2004

TDI en réanimation : à l’anneau latéral ?



Vignon et al Crit Care 20

Doppler tissulaire: *: E’ dépend des conditions de charge !*

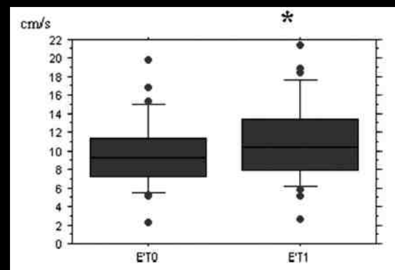
Influence of Acute Preload Changes on Mitral Annulus Velocity Measured by Tissue Doppler Echocardiography in Critically Ill Patients

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

E/E’ Non valable pour les pressions basses

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

Evaluation statique de la PTDVG:

Quand le rapport E/E' est dans la zone grise

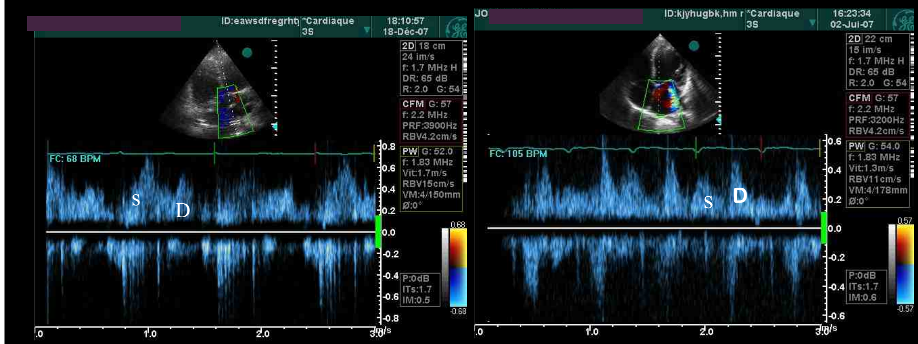
• Zone grise = 7 à 11

= > regardons le flux veineux pulmonaire

Pulmonary venous flow :

… Useful to predict high LVEDP

Systolic fraction of PVF : S VTI / (D VTI + D VTI)



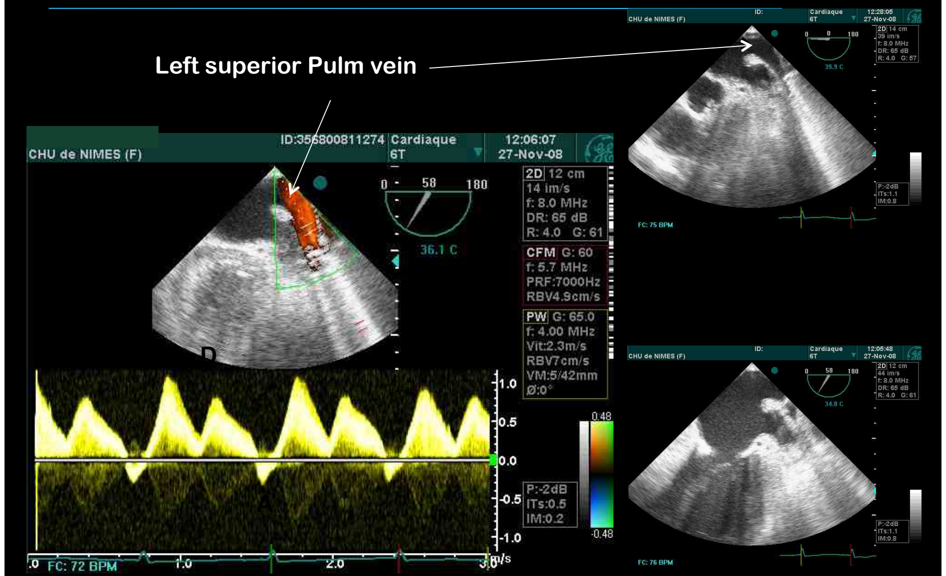
Low LVEDP = systolic fraction < 40 %

High LVEDP = systolic fraction > 40 %

Boussuges et al Crit care Med 2002

Pulmonary venous flow

Easier by TEE



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.

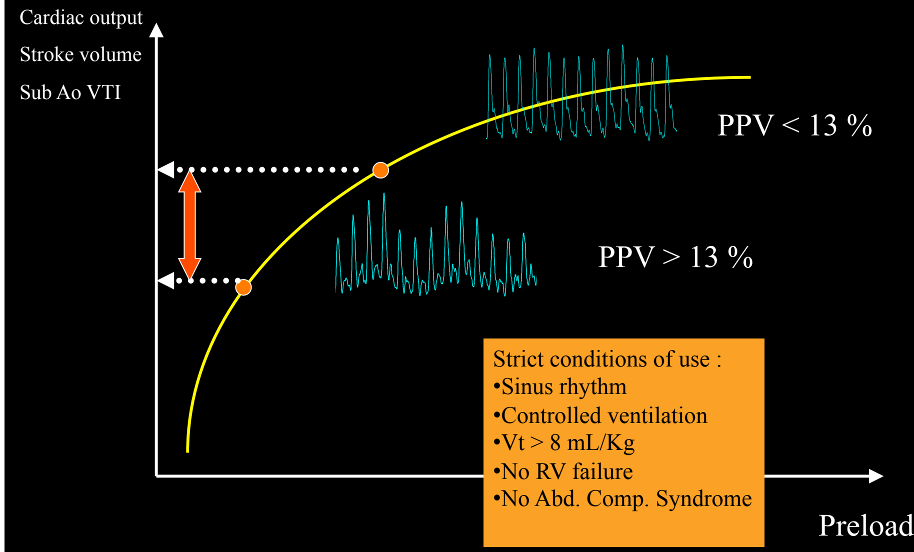
Vignon et al Crit Care 2007

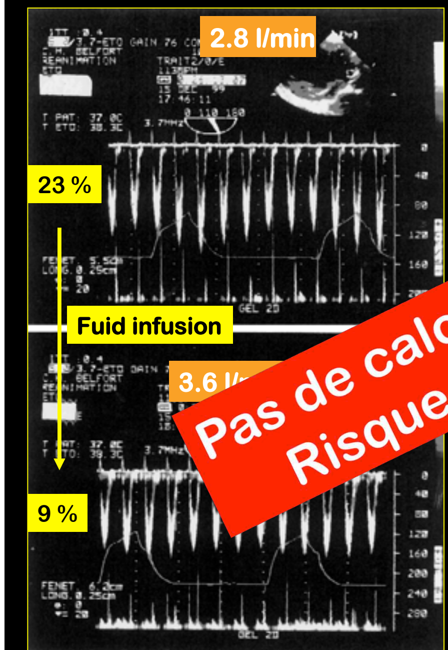
Deuxième approche–Indices dynamiques

Evaluation de la précharge par les interactions cardio pulmonaires

Dynamic indices, fluid responsiveness and the Frank-Starling curve

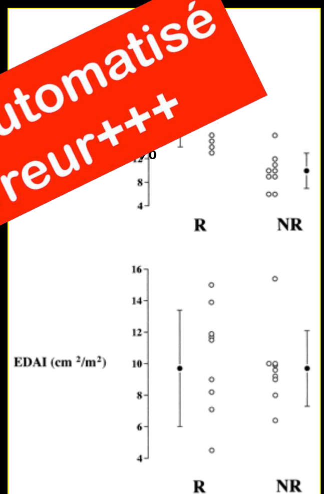
Pulse pressure variation (PPV)



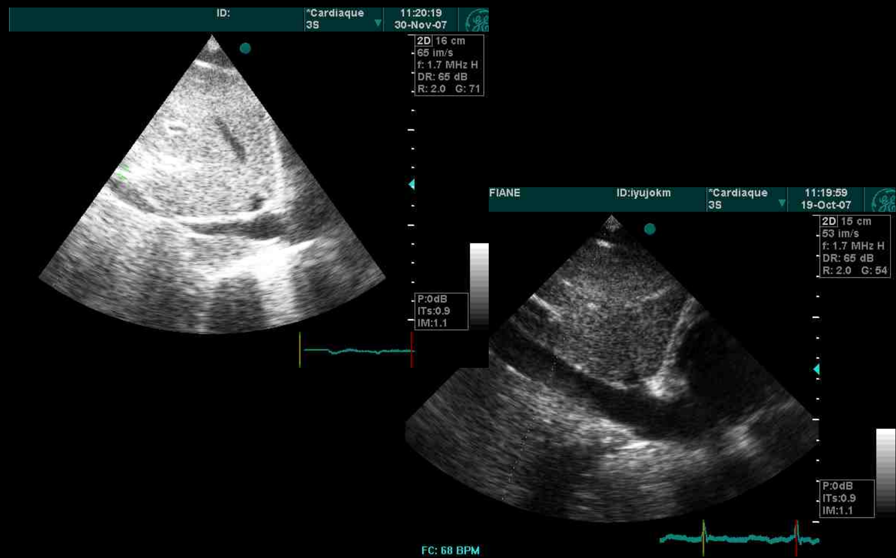


Respiratory Changes in Aortic Blood Velocity as an Indicator of Fluid Responsiveness in Ventilated Patients With Septic Shock*

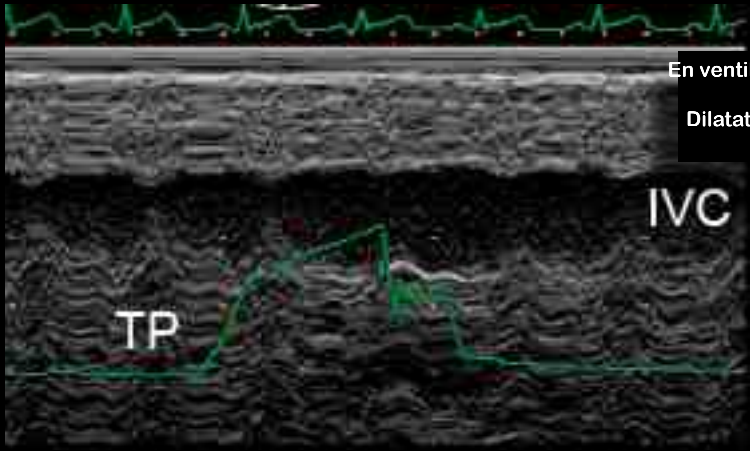
Feissel et al Chest. 2001;119:867-873



Variations respiratoires de la VCI: *un faux ami ?*



Variations respiratoires de la VCI en ventilation contrôlée:
Distensibilité de la VCI : max-min / (max + min /2)

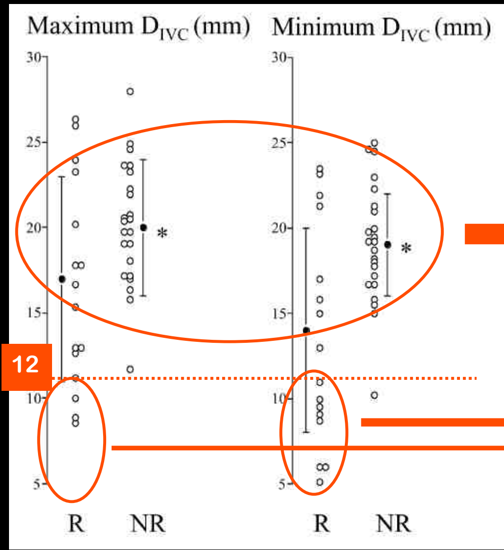


En ventilation mécaniqu
=
Dilatation inspiratoire de la VCI

Distensibilité de la veine cave inf en VAC

Vieillard Baron et al ICM 2004

Mesure du diamètre de la VCI



R = réponse + au remplissage

NR = réponse négative

Valeurs intermédiaires
Non informatives

Diamètre < 10 – 12 mm
Réponse au remplissage

Feissel et al Intensive Care Medicine

Variations respiratoires de la VCI : indicateur de remplissage en ventilation mécanique contrôlée (max-min/max+min/2) Seuil = 12 %

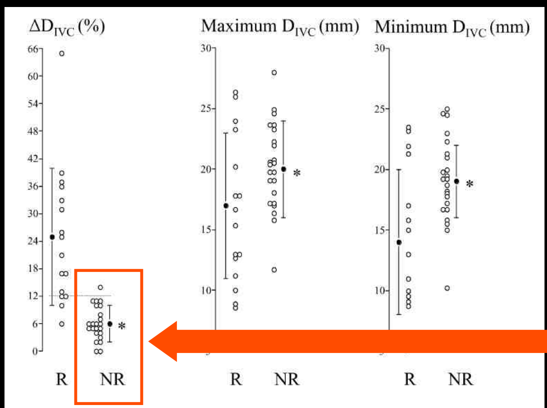
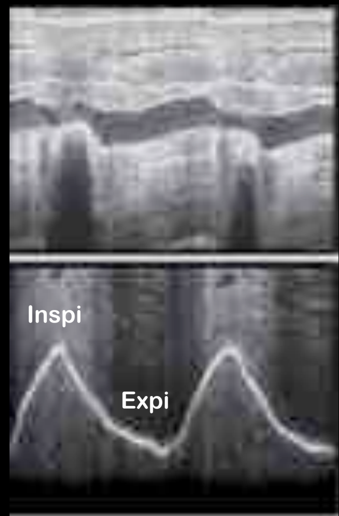


Fig. 3 Individual values (*open circles*) and mean ± SD (*closed circles*) of the minimum D_{IVC}, maximum D_{IVC} and ΔD_{IVC} before volume loading in responder (*R*) and non-responder (*NR*) patients. *P<0.05 R vs NR

Non répondeurs
au remplissage
=
VCI non collapsible

Feissel et al Intensive Care Medicine 2

Variations respiratoires de la VCI en ventilation spontanée :
Un collapsus inspiratoire



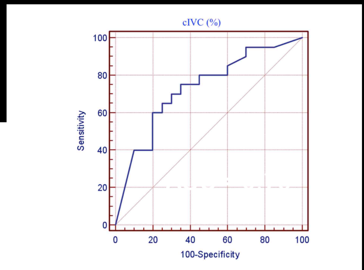
VCI

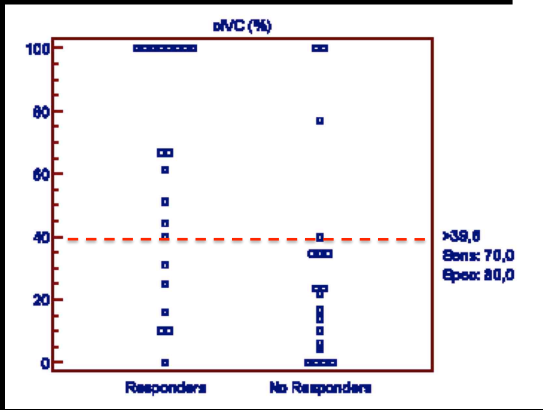
Diaphragme

Données personnelles

Variations respiratoires de la VCI en ventilation <u>spontanée</u> :
utile que si > 40 % (max-min/max)

Ici = collapsibilité =
compression en inspiration <u>en VS</u>





Muller et al Critical Care 2012

Diamètre et variations respiratoires de la VCI et PVC: recettes classiques
en ventilation spontanée

Attention : évaluer la PVC n'est pas prédire la réponse au remplissage

Diamètre de la VCI (mm)	Variations respiratoires de la VCI (%)	Valeur de POD (mmHg)
Bas : < 15	Collapsus inspiratoire de 100 %	0-5
Normal : 15-25	> 50	6-10
	< 50	11-15
Elevé : > 25	< 50	16-20
	Absentes	> 20

Luthra A, Echo made easy Anshan eds 2007
Wong SP, Practice of clinical echocardiography 2002
Brennan JASE 2007

Variations respiratoires de la VCI :
Résumé

- En ventilation mécanique contrôlée :
  - Dist. VCI > 12 % (formule max-min/(max+min/2) = hypovolémie
  - Dist. VCI < 12 % = pas d'hypovolémie
- En ventilation spontanée :
  - Coll. VCI > 40 % (formule max-min/max) = hypovolémie
  - Coll. VCI < 40 % = impossible de conclure

Respiratory variations of IVC diameter <u>in controlled ventilation:</u>
DIVC = max-min / (max + min /2)

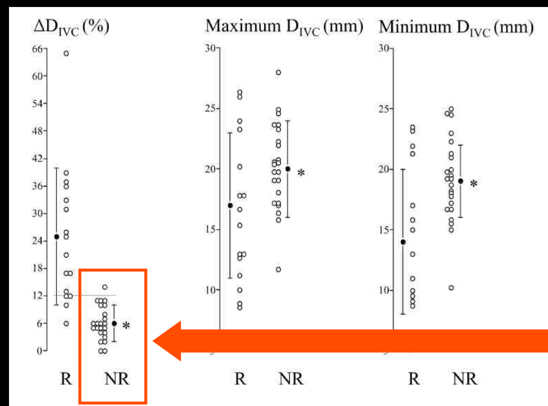


Fig. 3 Individual values (*open circles*) and mean ± SD (*closed circles*) of the minimum D_{IVC}, maximum D_{IVC} and ΔD_{IVC} before volume loading in responder (*R*) and non-responder (*NR*) patients. *$P<0.05$ R vs NR

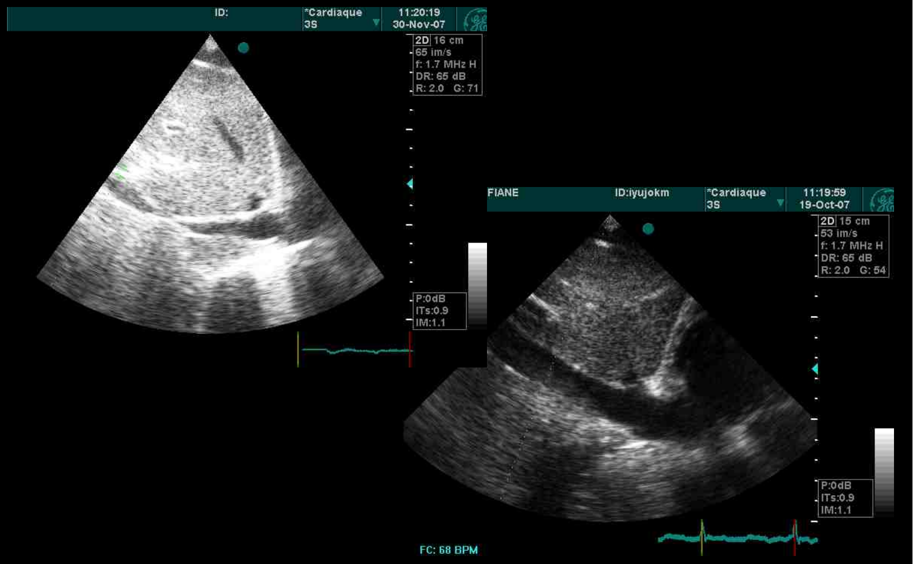
DIVC > 12%

=

Responder

Feissel et al Intensive Care Medicine 2004

Variations respiratoires de la VCI:
un faux ami en ventilation spontanée



Third step – Fluid challenge…
…and surrogates

Fluid challenge :
What is the definition of fluid responsiveness

- Fluid responsiveness is usually defined as a 10 to 15 % increase of cardiac output after a 250 to 500 mL of fluid infusion
- LVOT VTI recorded by echo is a valuable alternative to thermodilution cardiac output

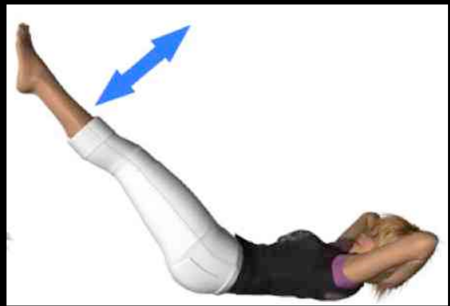
Monnet et al Curr Op Crit Care 2007

Fluid challenge :
A risk of fluid overload

- A fluid challenge is *"let's give some fluid and see what happens"*
- Half of fluid challenges based on clinical data are negative
- The risk is fluid overload
- Safer maneuvers are necessary

Vincent JL - Anesthesiology 2011
Teboul Chest 2002

Giving some fluids without fluid infusion ?



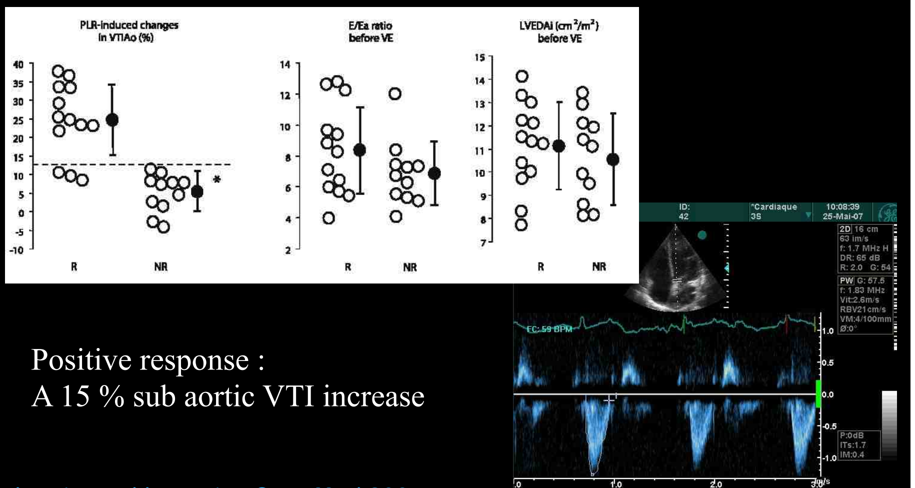
Fluid responsiveness:
The passive leg rising test (PLR)

PLR = mimics a volume expansion of about 300 ml

Valuable both in spontaneous or mechanical ventilation

Boulain et al Chest 2002
Monnet et al Critical Care Med 2006
Lafanechere et al Crit care 2006
Lamia et al Intensive Care Med 2007
Maizel et al Intensive Care Med 2007

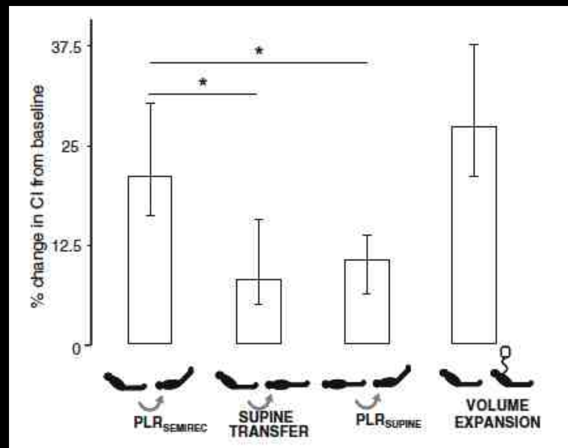
Fluid responsiveness:
The passive leg rising test (PLR) assessed by TTE



Positive response :
A 15 % sub aortic VTI increase

Lamia et al Intensive Care Med 2007

Lever passif de jambes :
La position compte…



Monnet et al Intensive Care Med 2009

Passive leg rising test :
…not always possible !

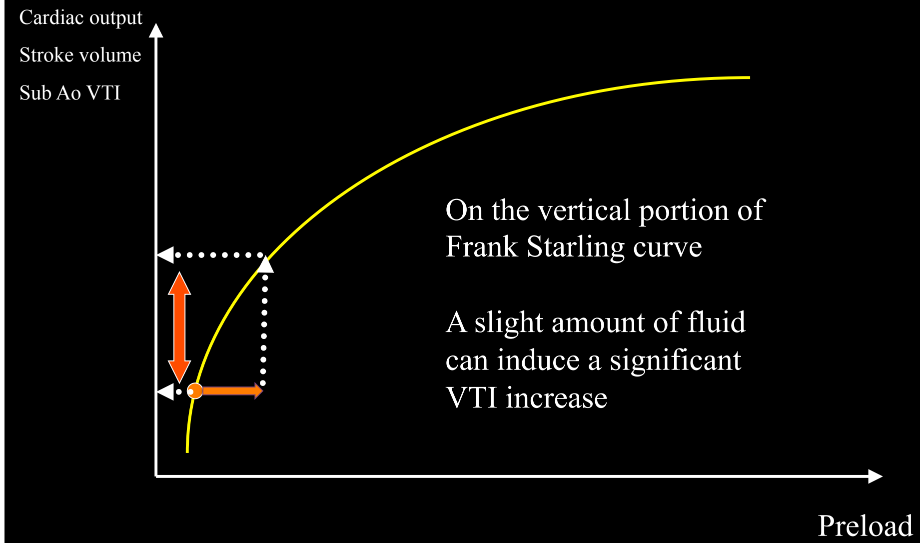
The mini fluid concept

"Let's Give Some Fluid and See What Happens" *versus* the "Mini-fluid Challenge"

"The general concept is … that the response to fluid challenge can be evaluated rapidly after a very limited amount of fluid . . ."

Vincent JL - Anesthesiology 2011

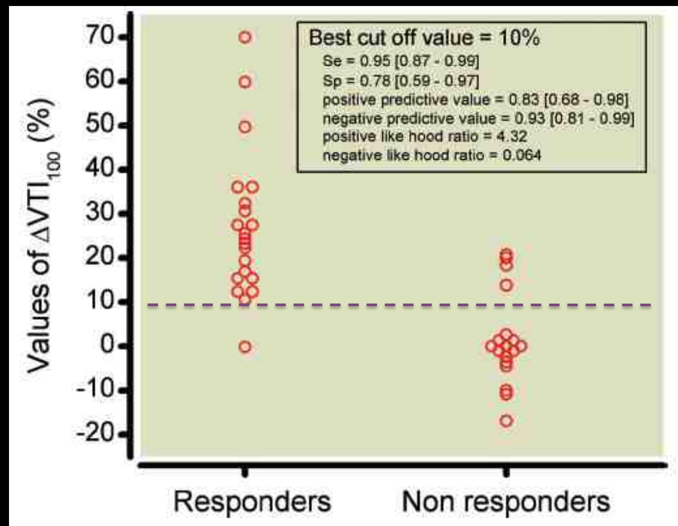
Mini fluid challenge : *the basics*



On the vertical portion of Frank Starling curve

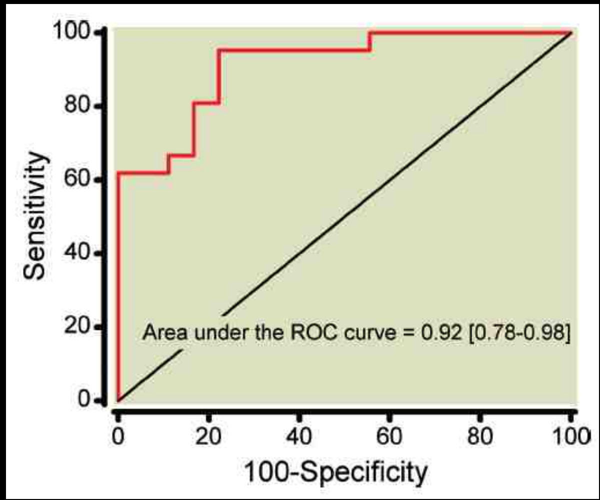
A slight amount of fluid can induce a significant VTI increase

Mini fluid challenge



Muller et al Anesthesiology 2011

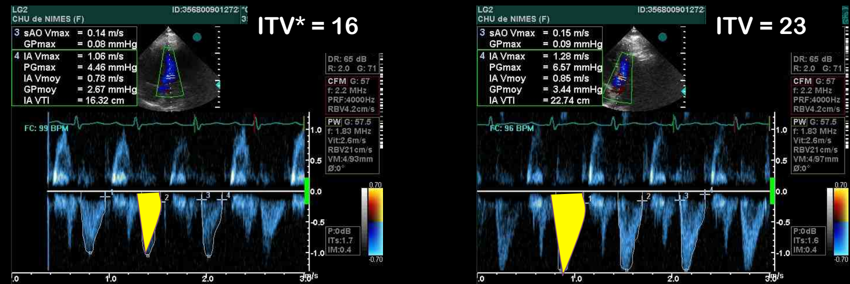
Mini fluid challenge



Muller et al Anesthesiology 2011

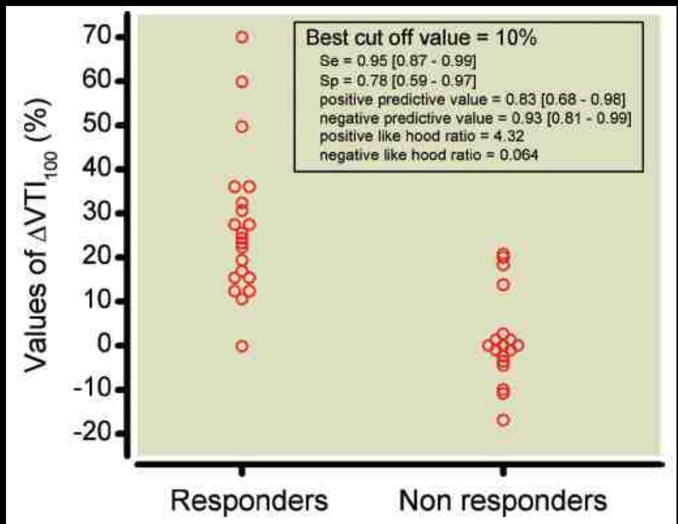
Exemple d' épreuve d' épreuve « mini fluid » positive

1 minute



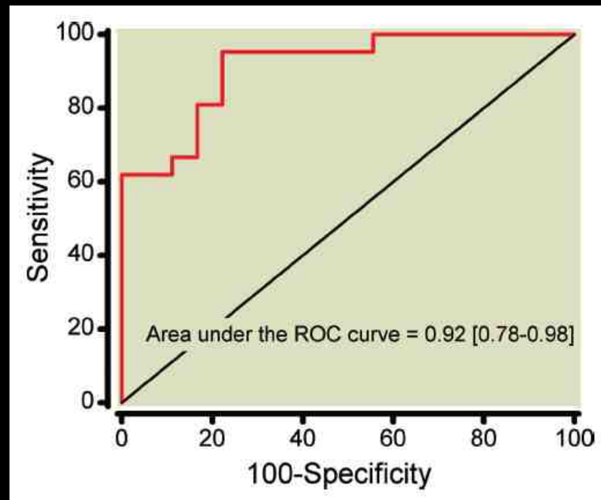
100 ml

Mini fluid challenge



Muller et al Anesthesiology 20

Mini fluid challenge :

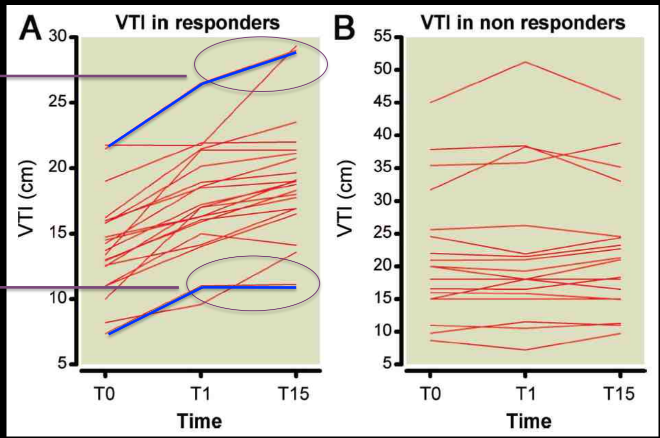


Muller et al Anesthesiology 201

Mini fluid challenge : reconstruction d'une courbe de Franck-Starling ?

Nouvelle épreuve souhaitable ?

Nouvelle épreuve non souhaitable ?



Muller et al Anesthesiology 201

Mini Fluid challenge : exemple

ITV = 5

100 ml

ITV = 7

400 ml

ITV = 12

PAM 45 => 55 mmHg

100 ml

ITV = 14

400 ml

PAM 55 => 75 mmHg

ITV = 15

VTI T_0

⬇

100 mL fluid infusion over 1 minute

⬇

VTI T + 1 minute

⬇

VTI increase > 10%

⬇	⬇
Yes (Responder)	**No (No responder)**
⬇	⬇
Fluid 400 ml over 15 minutes	**Stop fluid**

Fourth step …

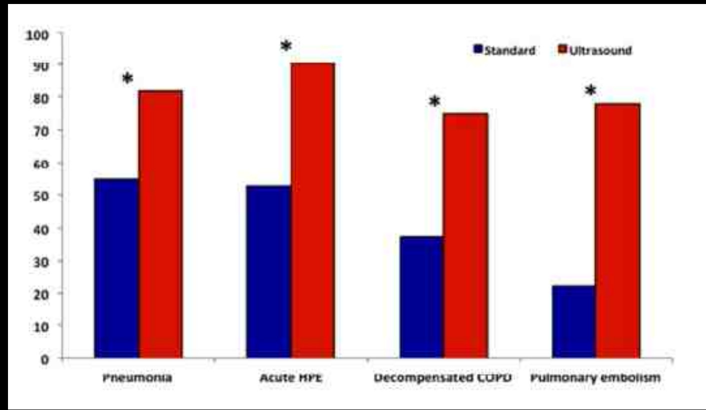
…Associer echo cardio et pleuro pulmonaire

Association echocardio et pleuro pulmonaire:
Une approche logique

	Lung	Heart
Pulmonary embolism	A-profile with deep venous thrombosis	RV failure (acute)
Acute haemodynamic pulmonary oedema	B-profile	High end-diastolic LV pressure
Decompensated COPD	A-profile	RV failure (chronic)
Pneumothorax	A'-profile	Non-specific
Pneumonia	C-profile A-profile plus PLAPS A/B-profile	Non-specific

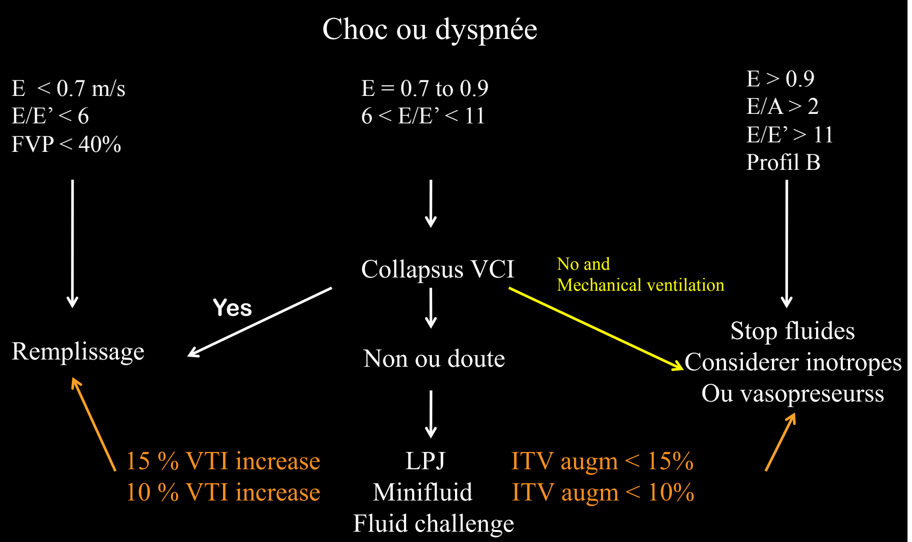
Silva et al Chest 2013

Association echocardio et pleuro pulmonaire:
Une approche logique



Silva et al Chest 2013

Evaluation de la volémie par échgraphie :
Proposition d'algorithme



Predicting fluid responsiveness with transthoracic echocardiography is not yet evidence based

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