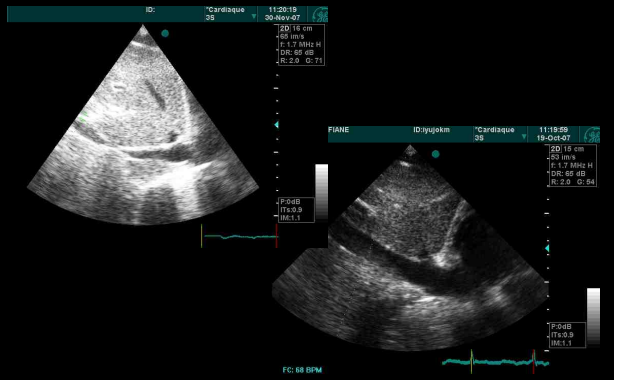
Secone étape étape – approche dynamique

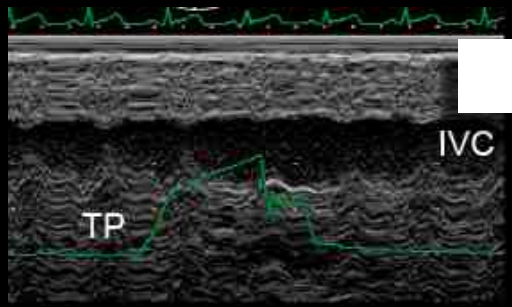
Prédiction de la réponse à l'expansion volémique

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



Variations respiratoires de la VCI en ventilation contrôlée:

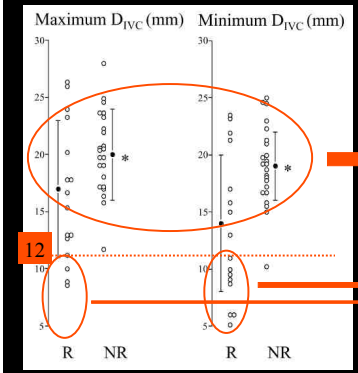
Distensibilité de la VCI : max-min / (max + min /2)



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 2004

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

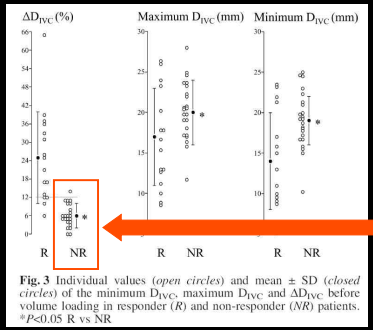
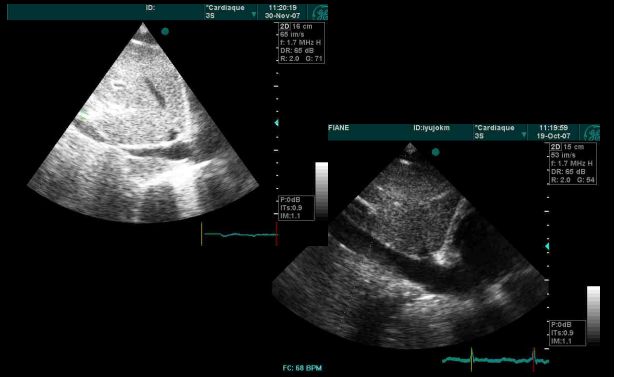


Fig. 3 Individual values (*open circles*) and mean ± SD (*closed circles*) of the minimum D_{IVC}, maximum D_{IVC} and ΔD_{IVC} before volume loading in responder (*R*) and non-responder (*NR*) patients. *$P<0.05$ R vs NR

Feissel et al Intensive Care Medicine 2004

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

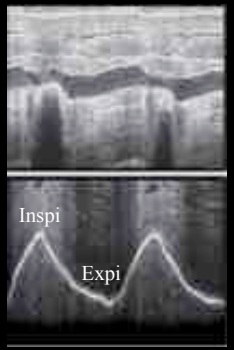


Diamètre et variations respiratoires de la VCI et PVC: recettes classiques en ventilation spontanée

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 en ventilation spontanée : *Un collapsus inspiratoire*



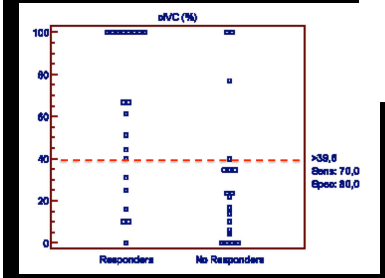
VCI

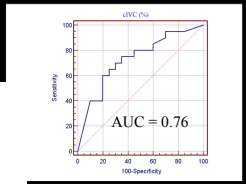
Diaphragme

Données personnelles

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

Ici = collapsibilité =
compression en inspiration en VS



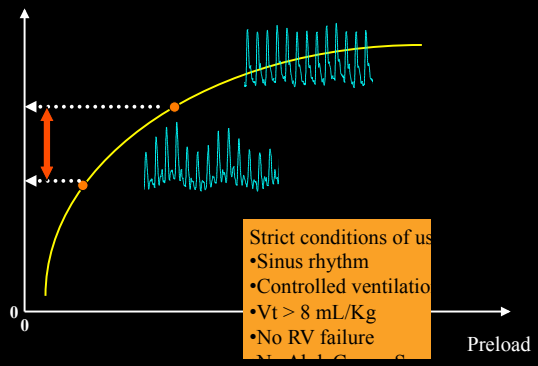


Muller et al Critical Care 2012

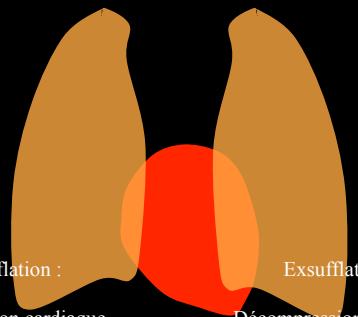
Variations respiratoires de la VCI : *Résumé*

- 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

Dynamic indices, fluid responsiveness and the Frank-Starling curve



Ventilation mécanique = intercations cardio-pulmonaires obligatoires



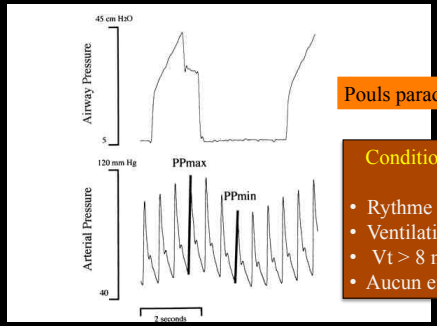
Insufflation :

Compression cardiaque
= Baisse du remplissage du VD
= Baisse de l'éjection du VD

Exsufflation :

Décompression cardiaque
= remplissage du VD
= augmentation l'éjection du VD

Variations respiratoires de la pression pulsée : précharge dépendance



Pouls paradoxal inverse

Conditions de validité :

- Rythme sinusal
- Ventilation contrôlée
- Vt > 8 ml/Kg
- Aucun effort ventilatoire

ΔPP = 100 x PPmax - PPmin / (Ppmax + PP min /2) – Seuil = 13 %

Insufflation mécanique → Diminution précharge VD / Augmentation post charge VD

↓

Diminution éjection VD

↓

Temps de transit pulmonaire
3 systoles
Inspiration => Expiration

Diminution précharge VG

↓

Diminution éjection VG

↓

Diminution expiratoire de pression artérielle → Pouls paradoxal inverse

---

Indices dynamiques de réponse au remplissage :

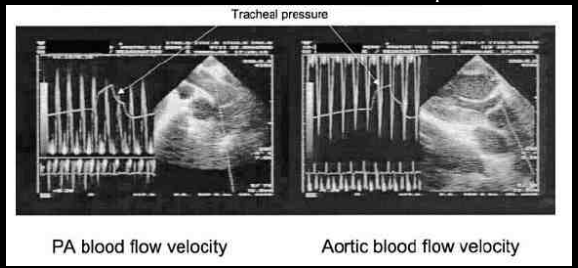
Inspiration :

Diminution vélocité Art Pulm

3 systoles →

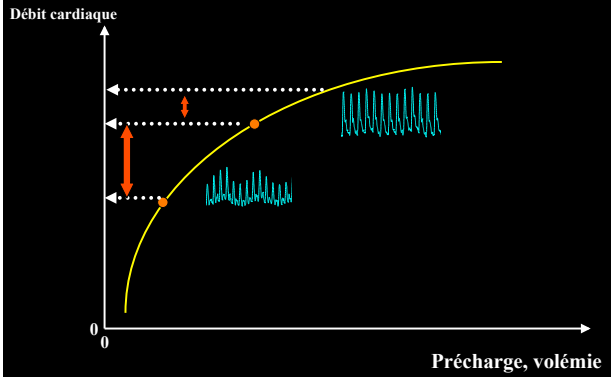
Expiration :

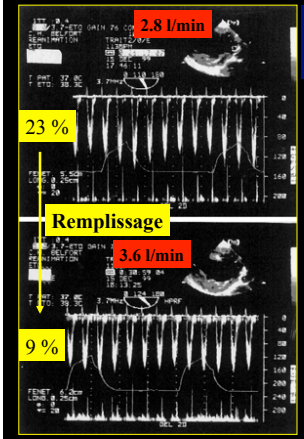
Diminution vélocité Aortique
« Pouls paradoxal inverse »



Vieillard- Baron et al AJRCCM 2003

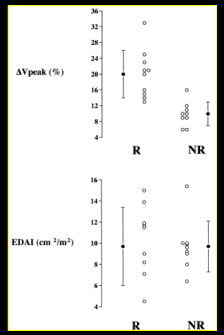
La force des indices dynamiques : appréhender la courbe de Starling

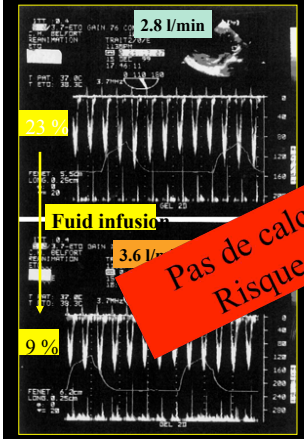




Respiratory Changes in Aortic Blood Velocity as an Indicator of Fluid Responsiveness in Ventilated Patients With Septic Shock

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

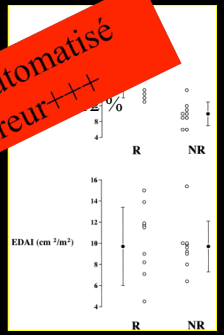




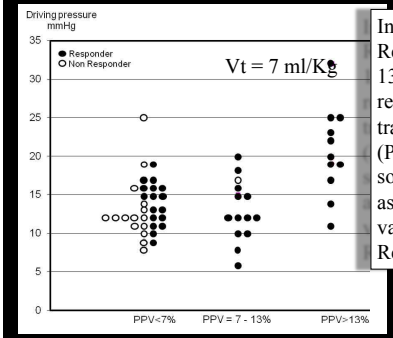
Respiratory Changes in Aortic Blood Velocity as an Indicator of Fluid Responsiveness in Ventilated Patients With Septic Shock

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

Pas de calcul automatisé
Risque d'erreur+++



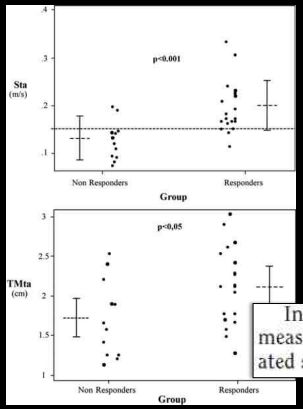
Indices dynamiques :
beaucoup de faux négatifs si Volume courant < 8 ml/Kg

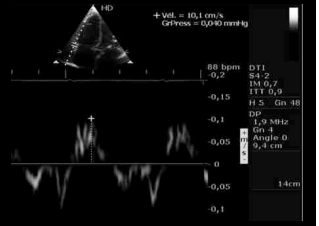


In 30 out of 41 Responders, PPV was < 13%. Using logistic regression, the transalveolar pressure (P_{plat} – PEEP) was the sole independent factor associated with a PPV value < 13% in Responders

Muller et al Intensive Care Med 2009

Cœur pulmonaire aigu = faux delta PP





Patients avec delta PP > 12%

In conclusion, echocardiographic measurement of Sta should be associated systematically with PPV

Mahjoub et al Critical Care Med 2009

Troisième étape – *Fluid challenge…*

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

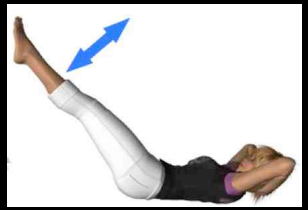
Monnet et al Curr Op Crit Care 2007

Fluid challenge :

- A 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)

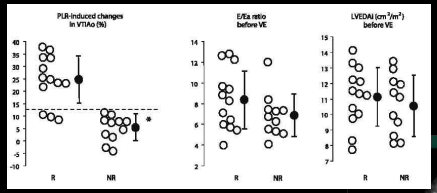
PLR = mimics a volume expansion of about 300 ml

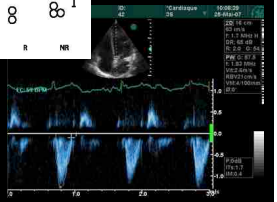
Valuable both in spontaneous or mechanical ventilation

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

Lever passif de jambes = PLR = expansion volémique virtuelle de 300 ml

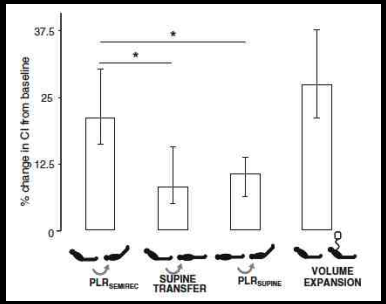




Lamia et al Intensive Care Med 2007

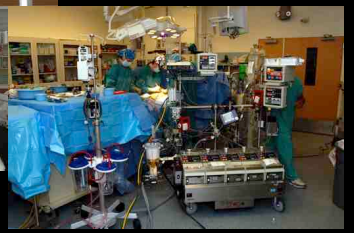
Lever passif de jambes :
La position compte…

Lever passif de jambes = PLR = expansion volémique virtuelle de 300 ml



Monnet et al Intensive Care Med 2009

Passive leg rising test :



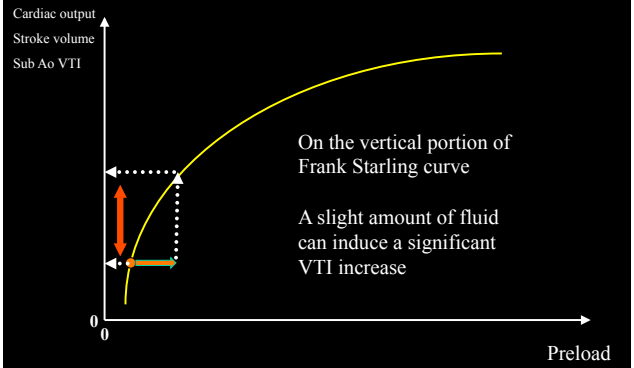
The mini fluid concept

"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

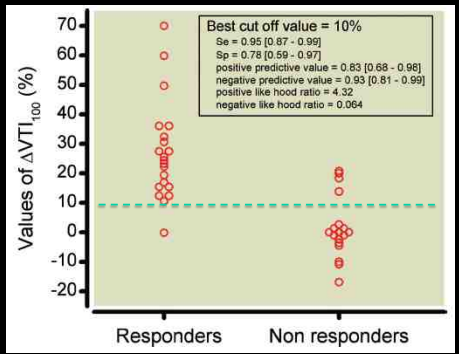
Mini fluid challenge : *the basics*



On the vertical portion of Frank Starling curve

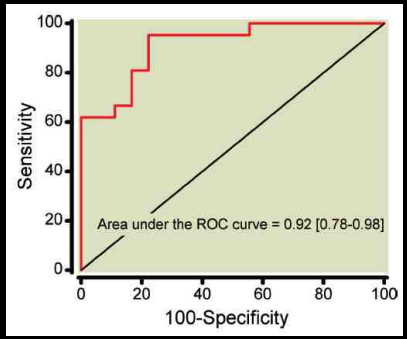
A slight amount of fluid can induce a significant VTI increase

Mini fluid challenge



Muller et al Anesthesiology 2011

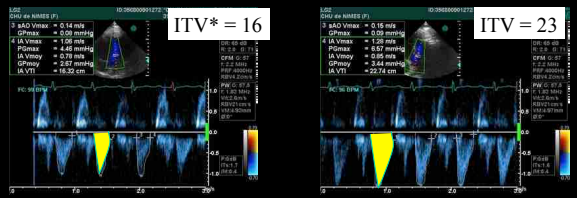
Mini fluid challenge



Muller et al Anesthesiology 2011

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

1 minute



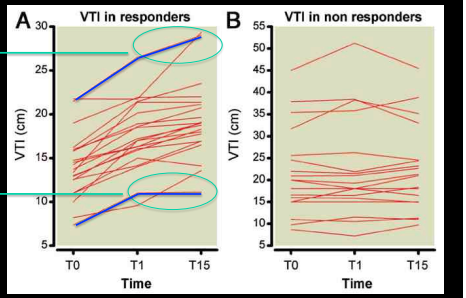
100 ml

*Variabilité inter et intra opérateur = 5 %

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

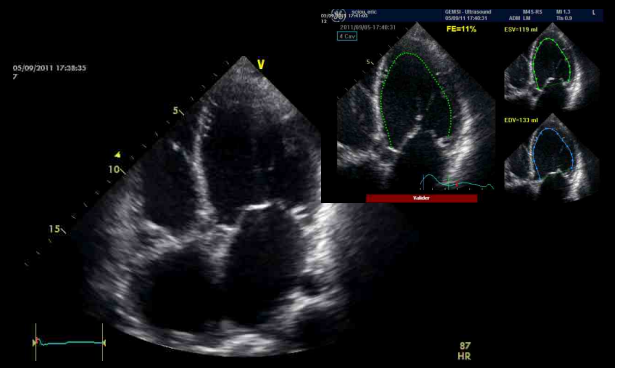
Nouvelle épreuve souhaitable ?

Nouvelle épreuve non souhaitable ?



Muller et al Anesthesiology 2011

Mini Fluid challenge : exemple



Mini Fluid challenge : exemple

ITV = 5

100 ml

ITV = 7

400 ml

PAM 45 => 55 mmHg

ITV = 12

100 ml

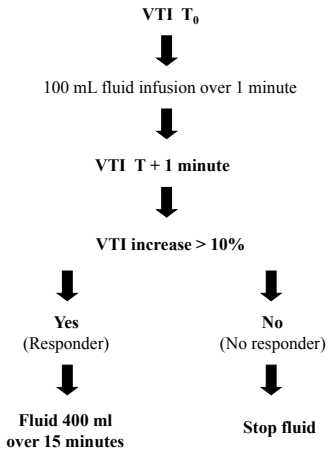
ITV = 14

400 ml

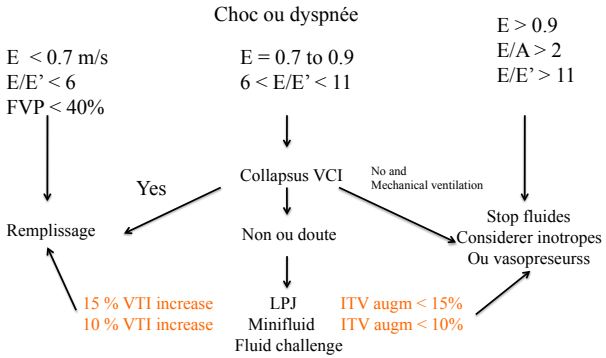
PAM 55 => 75 mmHg

ITV = 15

STOP

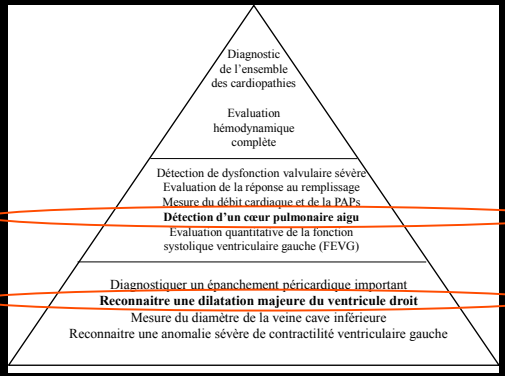


Evaluation de la volémie par échocardiographie : *Proposition d'algorithme*



Evaluation de la fonctionVD

Echocardiographie en réanimation : pyramide des compétences



Cholley et al Intensive Care Med 2007

Dilatation du VD : quantification

Normal | Dilatation modérée | Dilatation majeure

STDVD/STDVG < 0,6 | 0,6 < STDVD/STDVG < 1 | STDVD/STDVG > 1

Jardin et al Chest 1997

Dilatation du ventricule droit : évaluation qualitative ?

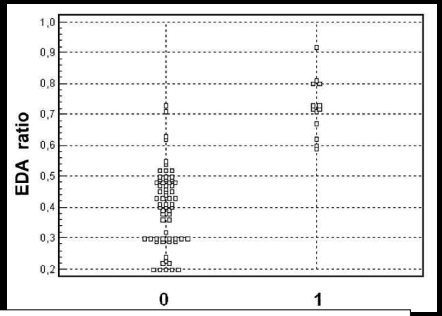
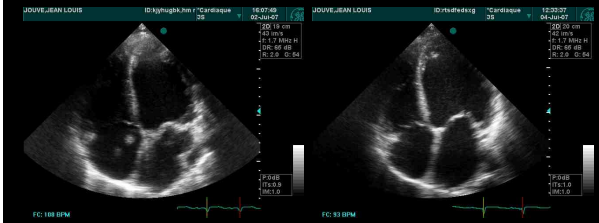


Fig. 3 Individual values of RV size, assessed on a long-axis view as the ratio of the end-diastolic area of the right ventricle over the end-diastolic area of the left ventricle (*EDA ratio*), in the two qualitative groups: *grade 0* normal RV size; *grade 1* moderately enlarged right ventricle

Vieillard Baron et al Intensive Care Med 2006

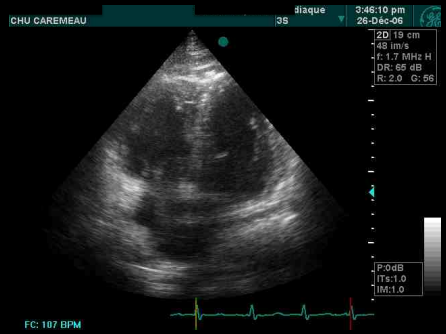
Dysfonction VD ??…



J_0 J_2

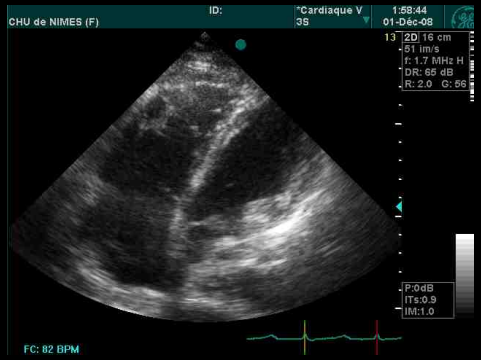
Patient de 45 ans, coronarien, ECG normal, choc et dyspnée

Dilatation aigue du ventricule droit



Patiente de 72 ans, dyspnée, crépitants, T° = 38°

Dilatation aigue du VD : état de choc, fracture bilatérale des fémurs



Septum paradoxal : « the D sign »

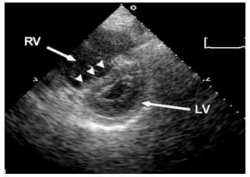
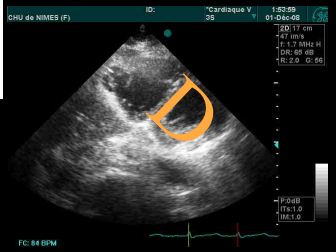
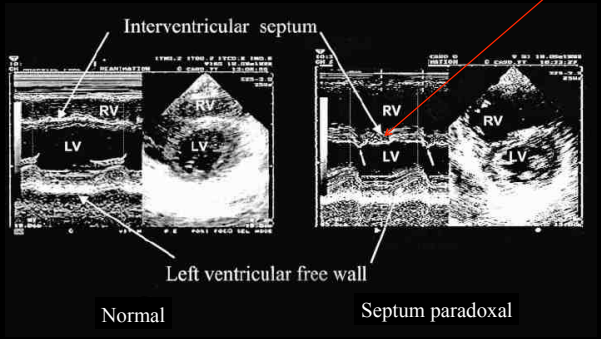


Figure 4. *Note the "D" shape of the LV in the parasternal short-axis view manifested here by flattening of the interventricular septum.*



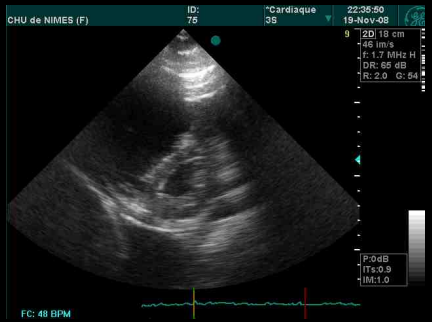
Lodato et al Echocardiography 2008

TM : bombement VD=>VG protodiastolique et télésystolique.

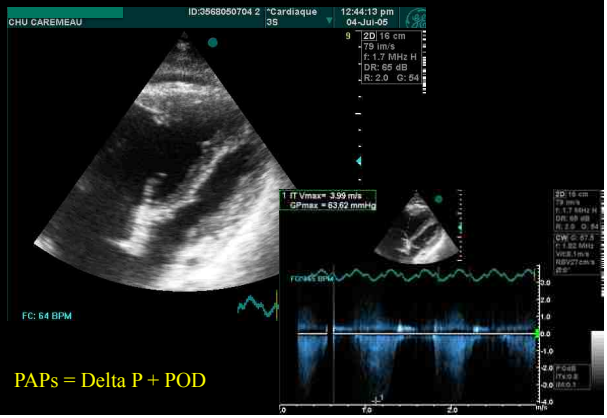


A. Vieillard – Baron Intensive Care Med 2001

Septum paradoxal : « the D sign »

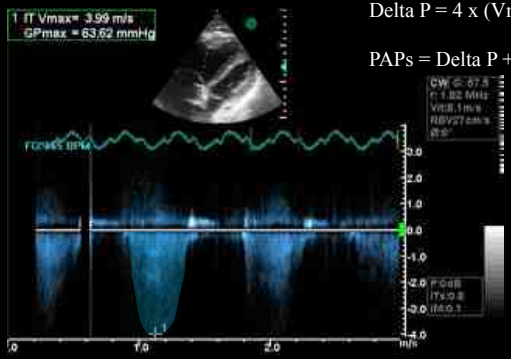


Cœur pulmonaire, mesure des pressions droites



PAPs = Delta P + POD

Mesure du niveau d'HTAP : Vmax de la fuite tricuspidienne

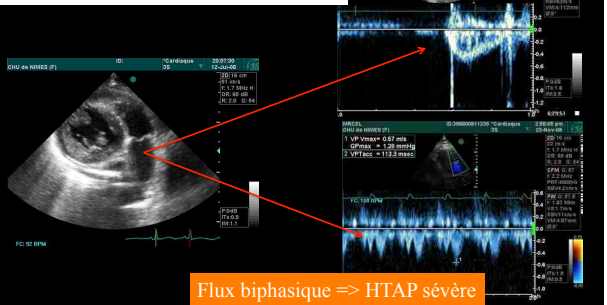


Delta P = 4 x (Vmax IT)^2

PAPs = Delta P + POD

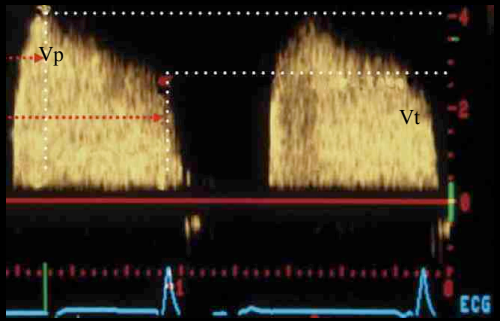
Mesure des pressions droites : *flux d'éjection pulmonaire*

Tacc	60	80	90	100	110
PAPs	52	43	38,5	34	29,5



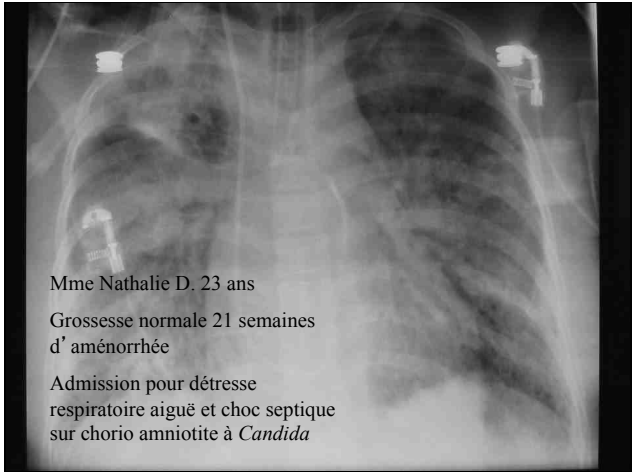
Flux biphasique => HTAP sévère

Mesure des pressions droites : *flux de régurgitation pulmonaire*



Vp = Vitesse protodiastolique
Vt = Vitesse télédiastolique

PAPm = 4Vp^2 + PVC
PAPd = 4Vt^2 + PVC
PAPs = 3PAPm – 2PAPd

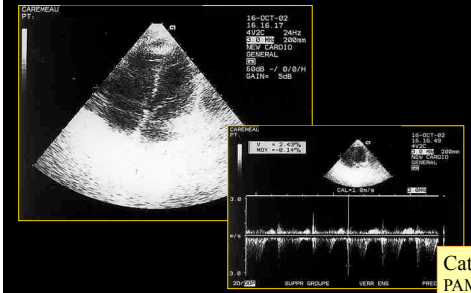


Mme Nathalie D. 23 ans

Grossesse normale 21 semaines d'aménorrhée

Admission pour détresse respiratoire aiguë et choc septique sur chorio amniotite à *Candida*

Cœur pulmonaire aigu au cours du SDRA :



Cathétérisme droit :

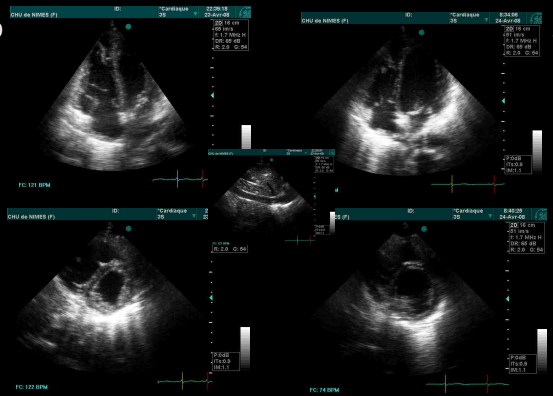
PAM	= 52
PAPs	= 45
PAPO	= 12
IC	= 2,7
SvO2	= 62 %

=> NO et baisse PEP => Amélioration clinique

Coeur pulmonaire aigu : patiente 40 ans péritonite, SDRA, PEP 12, Norad 2 mcg/Kg/min

J0

J1



Coeur pulmonaire aigu en réanimation:
Jusqu'à 25 % des patients en SDRA

Table 3 Independent factors associated with acute cor pulmonale (ACP) and patent foramen ovale (PFO)

ACP	OR[a]	95 % CI	*p* value
Plateau pressure, cmH_2O	1.07	0.98–1.17	0.13
$PaO_2/F_IO_2 \leq 100$	1.41	0.70–2.82	0.33
$PaCO_2 \geq 60$ mmHg	3.09	1.31–7.30	0.01
PFO	**OR[b]**	**95 % CI**	***p* value**
Age >60 years	2.07	0.91–4.72	0.08
Respiratory-system compliance <25 mL/cmH_2O[c]	2.06	0.82–5.17	0.12
Tidal volume, mL/kg of predicted body weight	1.24	0.89–1.74	0.20

Lhéritier et al Intensive Care Med 2013

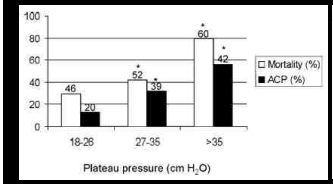
Défaillance ventriculaire droite et pressions de ventilation

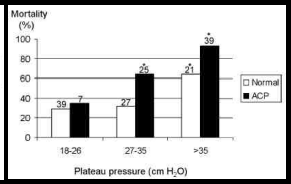
Intensive Care Med (2007) 33:444–447
DOI 10.1007/s00134-007-0552-z

ORIGINAL

François Jardin
Antoine Vieillard-Baron

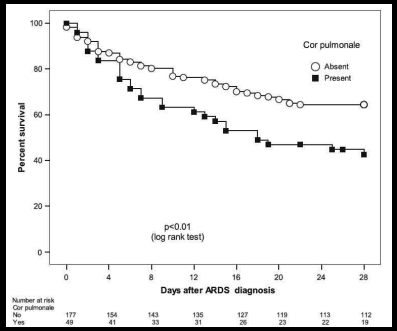
Is there a safe plateau pressure in ARDS?
The right heart only knows





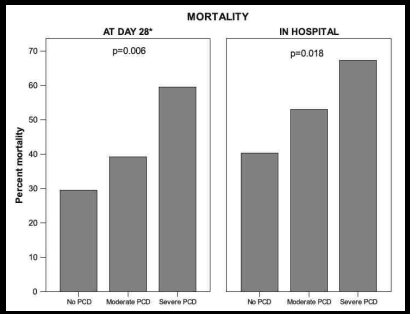
Vieillard Baron et al Intensive Care Med 2007

Coeur pulmonaire aigu en réanimation: Pronostic du SDRA



Boissier et al Intensive Care Med 2013

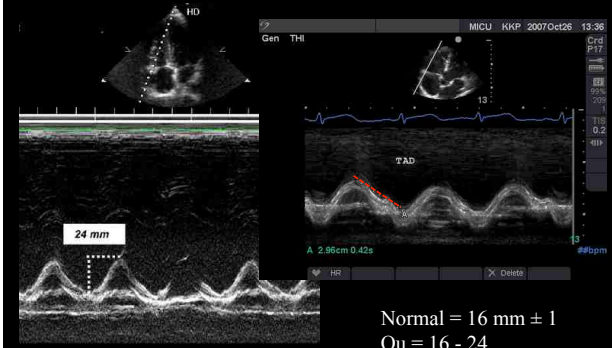
Coeur pulmonaire aigu en réanimation: Pronostic du SDRA



Boissier et al Intensive Care Med 2013

Fonction systolique ventriculaire droite : TAPSE

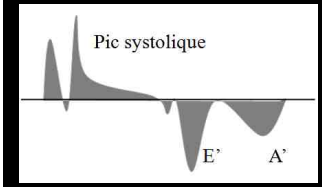
Tricuspid Annular Plane Systolic Excursion

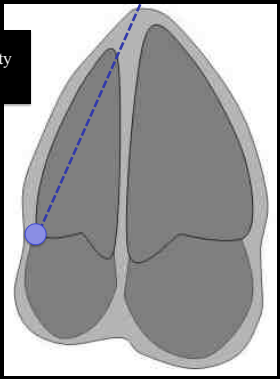


Normal = 16 mm ± 1
Ou = 16 - 24

Doppler tissulaire à l'anneau tricuspide

Tricuspid Annulus peak Systolic velocity
= TAPSV





Fonction systolique VD : *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

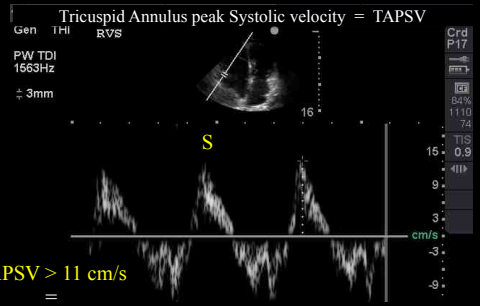
	LV (Mean of 4 Walls)				RV (Free Wall)		
	S' (pwTDI)	S' (cTDI)	e' (pwTDI)	a' (pwTDI)	S' (pwTDI)	e' (pwTDI)	a' (pwTDI)
Female sex							
Feasibility, no. (%)	652 (98%)	657 (99%)	652 (98%)	652 (98%)	648 (98%)	648 (98%)	648 (98%)
<40 y, cm/s	8.9±1.1	7.2±1.0	14.6±2.3	8.8±1.9	13.0±1.8	14.7±2.9	12.4±3.5
40–60 y, cm/s	8.1±1.2	6.5±1.0	11.3±2.4	10.0±1.9	12.4±1.9	13.1±2.9	15.0±3.5
>60 y, cm/s	7.2±1.2	5.7±1.1	8.2±3.2	10.6±1.9	11.8±2.0	11.0±2.3	16.1±3.1
All, cm/s	8.2±1.3	6.6±1.1	11.8±3.2	9.7±2.0	12.5±1.9	13.3±3.0	14.4±3.7
Male sex							
Feasibility, no. (%)	590 (98%)	601 (99%)	590 (98%)	590 (98%)	586 (97%)	586 (97%)	586 (97%)
<40 y, cm/s	9.4±1.4	7.6±1.2	14.1±2.7	9.1±1.7	13.2±2.0	14.5±2.9	12.3±3.5
40–60 y, cm/s	8.6±1.3	6.9±1.3	10.7±2.3	10.4±1.6	12.8±2.2	12.5±3.2	14.3±3.7
> y, cm/s	8.0±1.3	6.4±1.2	8.2±1.9	11.1±1.6	12.5±2.3	11.0±3.0	15.8±4.2
All, cm/s	8.6±1.4	6.9±1.3	10.8±3.0	10.3±1.7	12.8±2.2	12.5±3.3	14.2±3.9

Data are presented as mean±SD tissue Doppler velocities from 1266 healthy individuals for the stratified age groups, unless otherwise indicated. Level of significance is specified in the Mitral Annular Velocities and Tricuspid Annular Velocities subsections of the Results section.

Dalen et al Circulation 2010

Fonction systolique ventriculaire droite : TAPSV

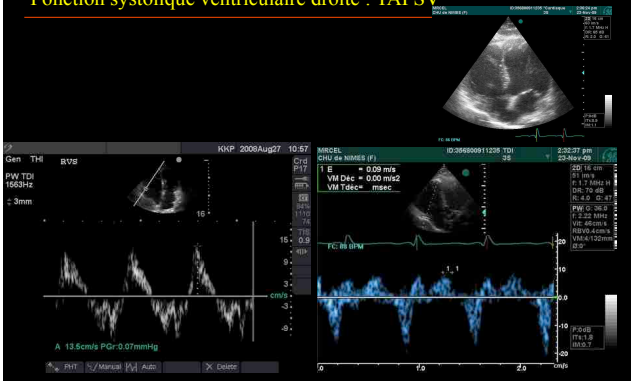
Tricuspid Annulus peak Systolic velocity = TAPSV



TAPSV > 11 cm/s
=
Fonction VD
et
PAPs normales

Saxena et al *Echocardiography* 2006

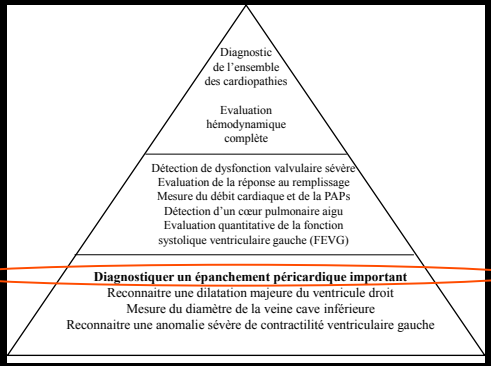
Fonction systolique ventriculaire droite : TAPSV



Saxena et al *Echocardiography* 2006

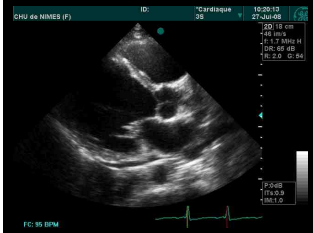
Péricarde

Echocardiographie en réanimation : pyramide des compétences



Cholley et al Intensive Care Med 2007

Epanchement péricardique



Minime

Majeur

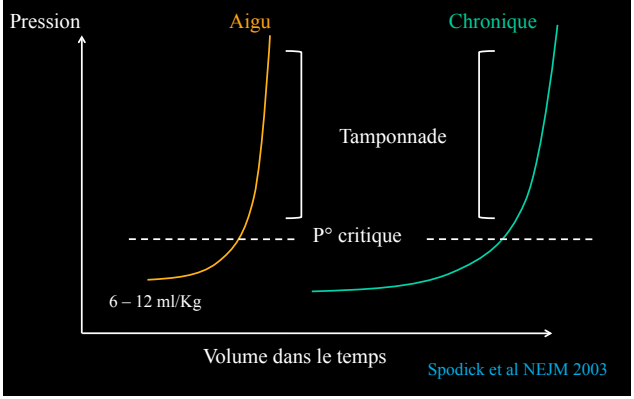
Epanchement péricardique : quantification

Tableau 3 : Quantification des épanchements péricardiques et signes de tamponnade

Evaluation semi quantitative en mode TM (PSGA)	*Signes de tamponnade*
• Décollement systolique avec cinétique du péricarde pariétal postérieur conservée. • Décollement systolique avec péricarde pariétal postérieur rectiligne. • Décollement systolo-diastolique < 10 mm en diastole et décollement antérieur. • Décollement systolo-diastolique > 10 mm en diastole et décollement antérieur.	• Compression OD, VD • Plus rarement compression OG, VG • Dilatation de la VCI avec absence de variations respiratoire du diamètre de cette dernière.

SFAR 2008

Tamponnade : *importance de la vitesse de constitution*



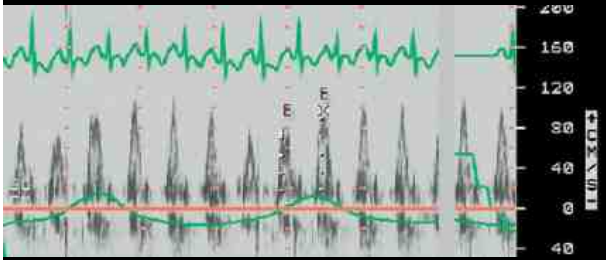
Spodick et al NEJM 2003

Tamponnade : principes du diagnostic échographique

Tamponnade =

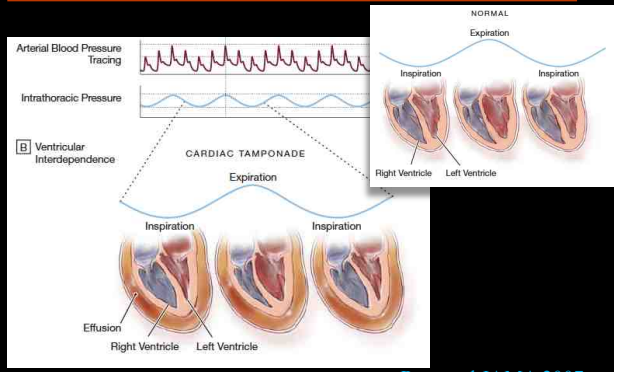
1. Epanchement péricardique
2. Associé à des signes de compression :
   - Pouls paradoxal échographique en VS
   - Compression OD, VD, plus rarement OG, VG
   - Dilatation majeure de la VCI
   - Septum paradoxal inspiratoire en VS
   - Swinging heart

Pouls paradoxal échographique (! VS !)



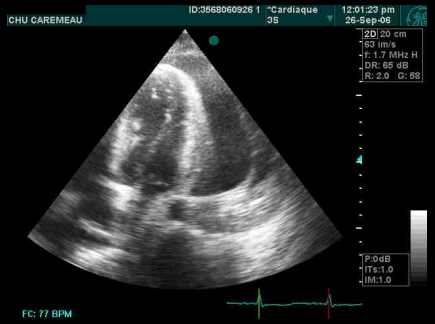
Wann et al JASE 2008

Tamponnade : septum paradoxal inspiratoire (! VS !)



Roy et al JAMA 2007

Epanchement péricardique

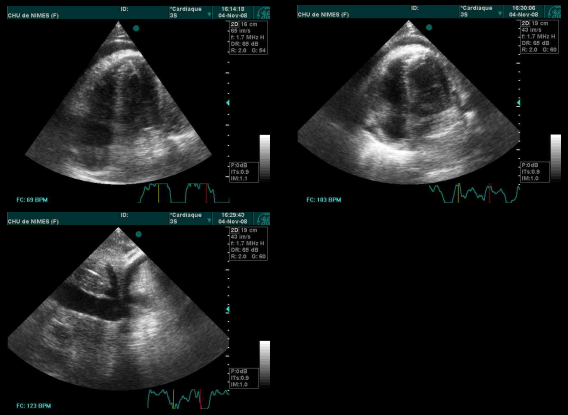


« Swinging Heart »

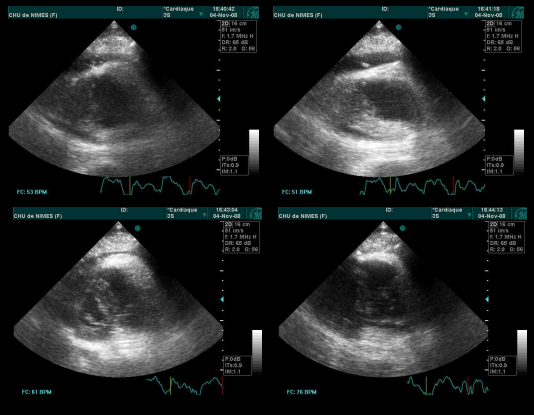
Une hépatite non cholestatique…

« Swinging Heart »

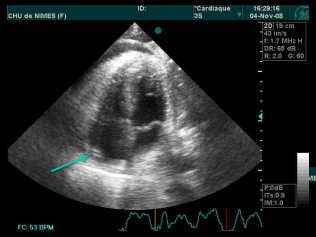
Epanchement péricardique : lymphome, choc septique



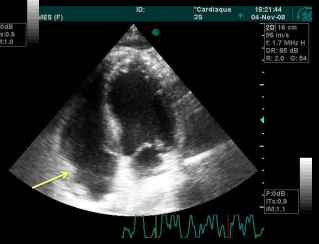
Epanchement péricardique : drainage



Epanchement péricardique : drainage

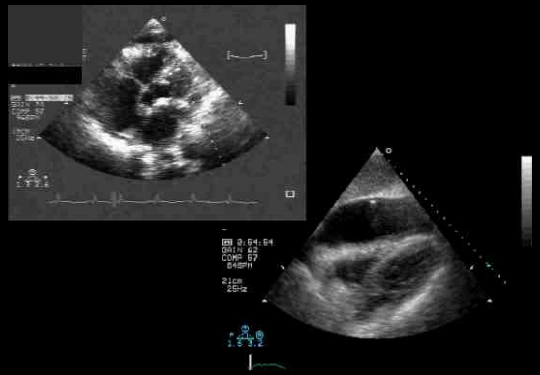


PAM = 55 mmHg
Norad = 4 mcg/Kg/min

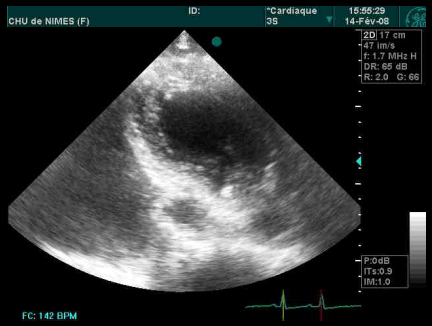


PAM = 80 mmHg
Norad = 1 mcg/Kg/min

Tamponnade : *collapsus des cavités droites*

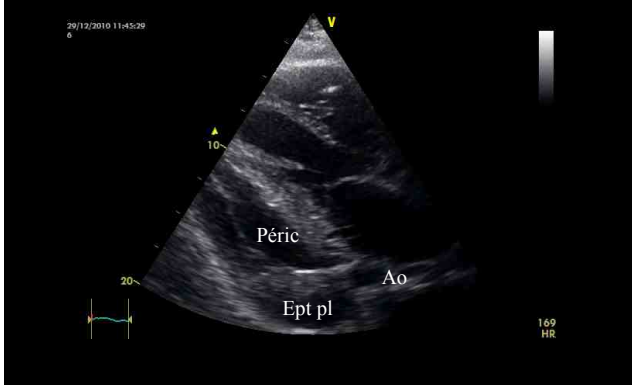


Epanchement péricardique ?

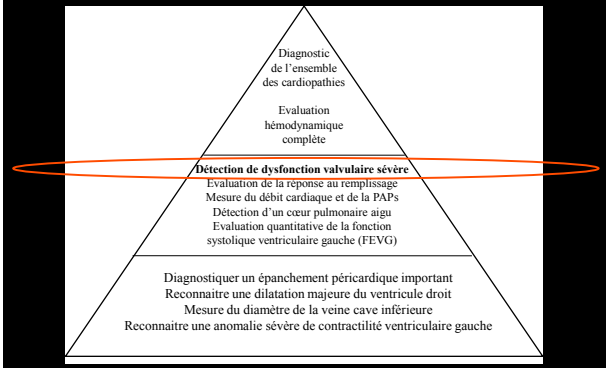


Quel est votre diagnostic ?

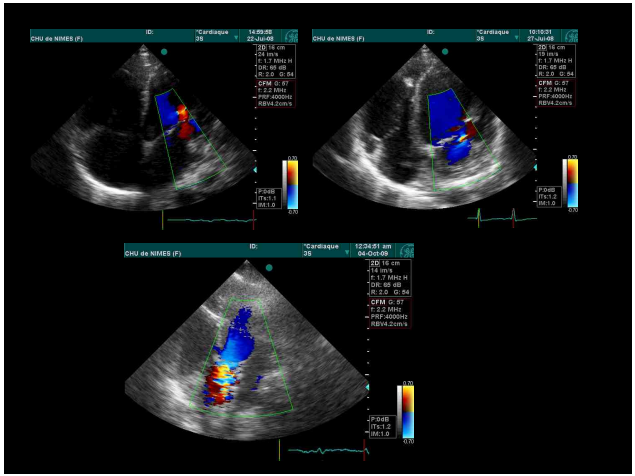
Epanchement péricardique ET pleural



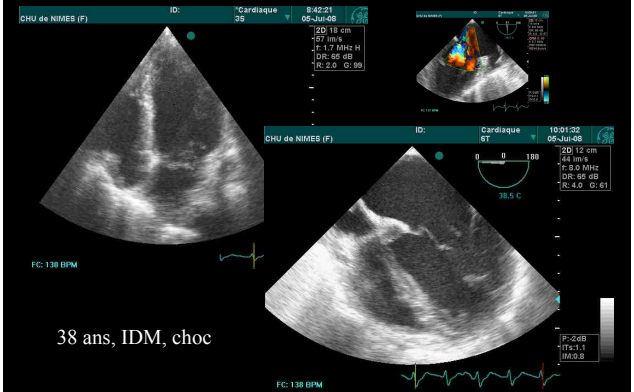
Echocardiographie en réanimation : pyramide des compétences



Cholley et al Intensive Care Med 2007



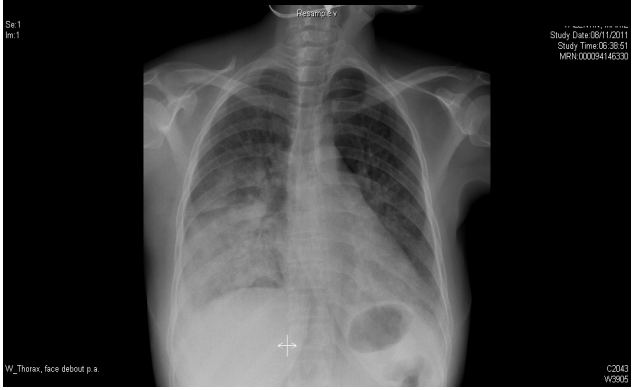
Valvulopathies en réanimation : il faut connaître un peu…



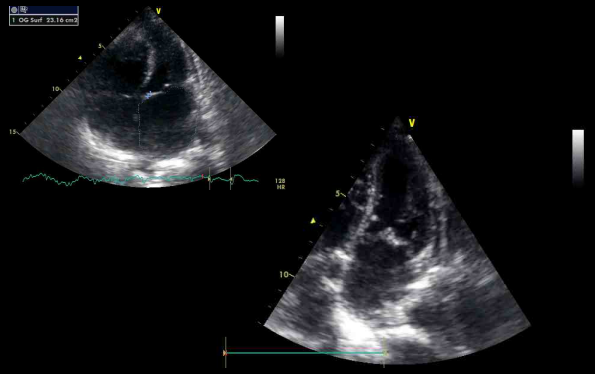
38 ans, IDM, choc

Valvulopathies en réanimation : il faut connaître un peu…

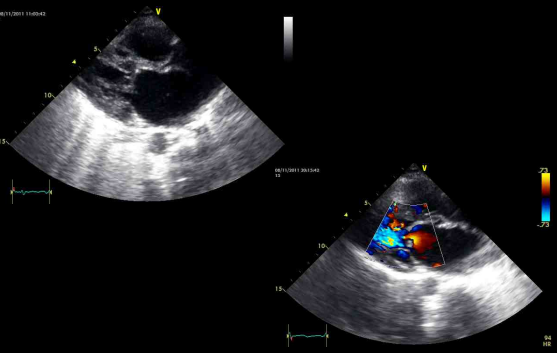
Patiente de 30 ans, sans ATCD, grossesse 30 SA, détresse respiratoire aigue



Valvulopathies en réanimation : il faut connaître un peu…



Valvulopathies en réanimation : il faut connaître un peu…



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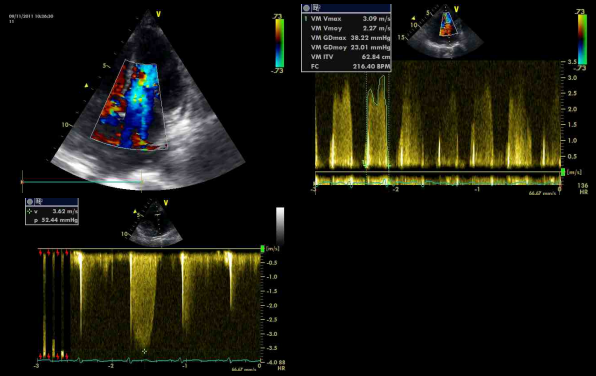

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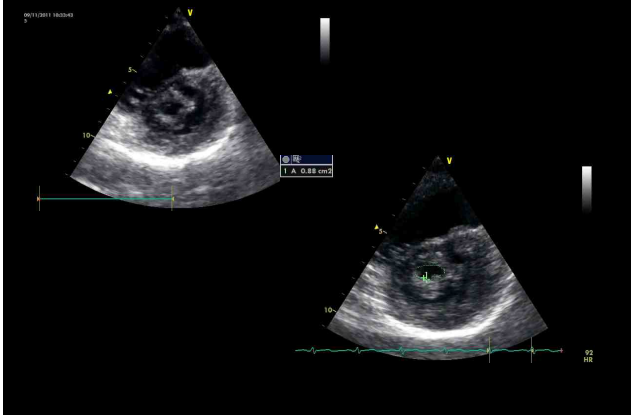
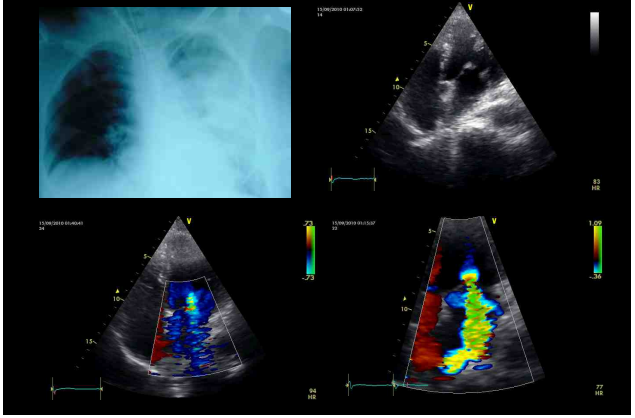
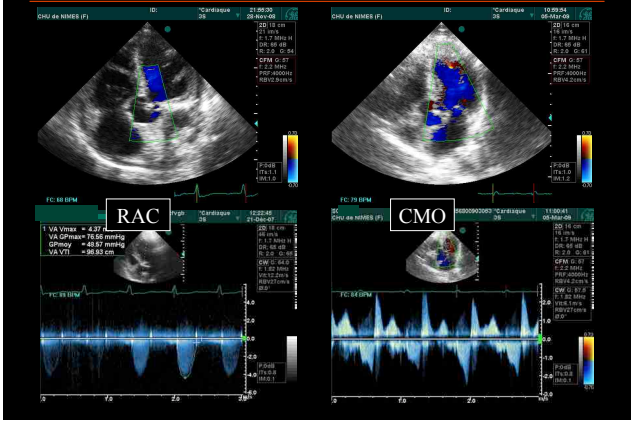


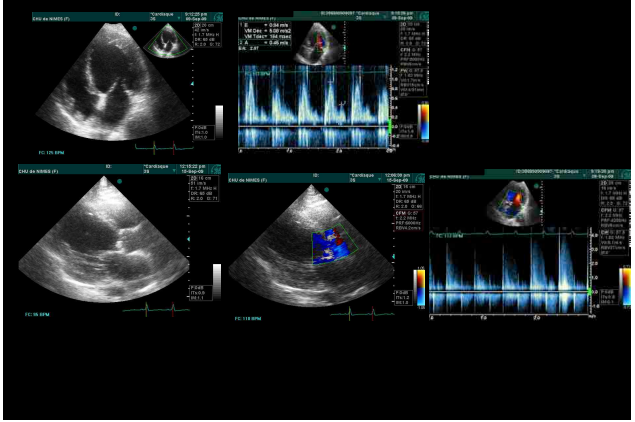
Une pneumopathie qui ne s'améliore pas



Valvulopathies en réanimation : il faut connaître un peu…



Patiente de 48 ans, détresse respiratoire aiguë fébrile , Hémiplégie gauche



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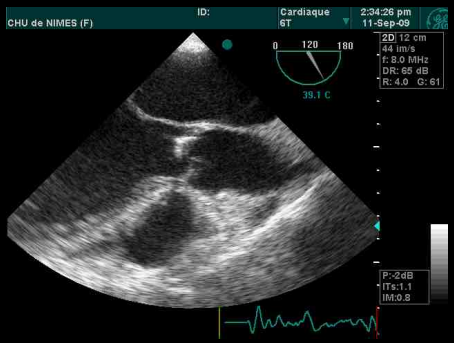


Echocardiographie et états de choc : résumé

Etat de choc
objectifs : PAM > 65 mmHg, diurèse > 0,5 ml/Kg/h et lactates < 2 mmol/l

1. Tamponnade ? => Drainage
2. Hypovolémie ? => Remplissage
3. Vasoplégie ? => Noradrénaline
4. Dysfonction VG ? => Inotropes +/- ECMO
5. Dysfonction VD ? => Réglage ventilateur, PEP, NO +/- ECMO
6. Valvulopathie aigue sévère ? => Chirurgie

Echocardiographie et états de choc : résumé

Etat de choc
objectifs : PAM > 65 mmHg, diurèse > 0,5 ml/Kg/h et lactates < 2 mmol/l

1. Tamponnade ? = Epanchement + Colla OD + VCI dilatée
2. Hypovolémie ? = E < 0,7, E/E' < 7, colla VCI 100 %, delta ITV > 10
3. Dysfonction VG ? = FEVG < 40 %, visuelle ou mesurée
4. Dysfonction VD ? = dilat VD + SP
5. Vasoplégie ? = PAM basse + ITV > 20
6. Valvulopathie aigue sévère ? = flux couleur massif avec zone de convergence

Echocardiographie en réanimation : incontournable ?

POINTS OF VIEW

All intensivists need echocardiography skills in the 21st century

Critical Care and Resuscitation • Volume 9 Number 3 • September 2007 — Ian M Seppelt

For a patient whose condition becomes unstable at 03:00, it is reasonable to expect a focused echo examination to answer the following questions:

- Is the heart working?
- Is it really full or really empty?
- Is there an acute valve rupture with torrential regurgitation?
- Is there an acute cardiac rupture or ventricular septal defect?
- Is there a tamponade?

There are thus three levels of echocardiography training for intensive care practice:

- Level 1— the focused clinical examination, 24 hours per day, to answer immediate clinical questions.
- Level 2 — the trained echocardiographer, with more advanced knowledge and skills, and ongoing maintenance of skills and quality assurance. Ideally there will be at least one of these in every ICU.
- Level 3 — the program director or researcher in critical care echocardiography.

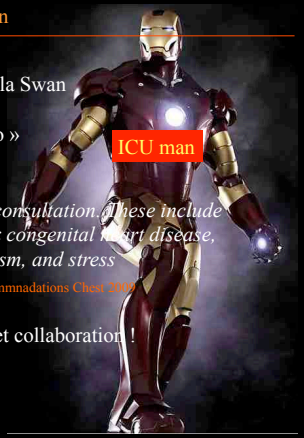
Most intensive care trainees recognise and want this. The challenge for us now is to make it happen.

Focused = 1 question simple
1 réponse simple

Seppelt IM Crit Care Resusc 2007

Echocardiographie en réanimation

- Ne pas reproduire les erreurs de la Swan
- Pas de syndrome du « super héro »



- « *Situations require cardiology consultation. These include prosthetic valve function, complex congenital heart disease, cardiac source of systemic embolism, and stress echocardiography* ». ACCP SRLF recommnadations Chest 2009
- Echo en réa = rigueur, humilité et collaboration !