# DIU TUSAR

***Bordeaux – Mardi 16 décembre 2025***

# Exploration du coeur droit et de la voie pulmonaire

Philippe Vignon

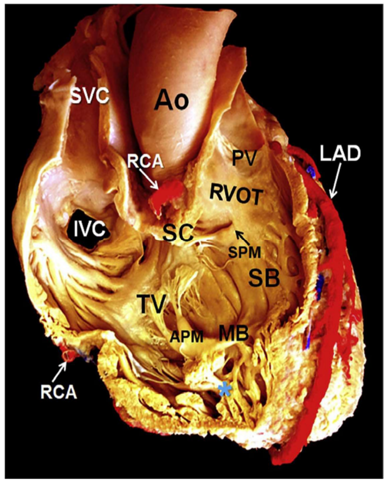
Réanimation Polyvalente
Inserm CIC 1435
CHU Limoges

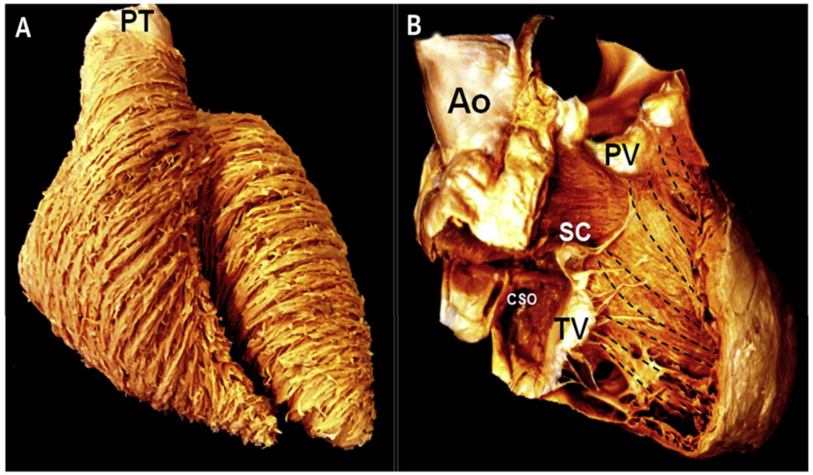
# Ventricule droit

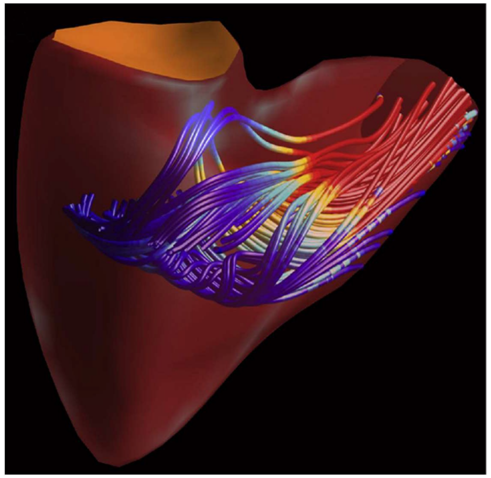
- Pyramide tronquée enroulée en croissant autour du VG
- Antérieur dans le thorax (position rétrosternale)
- Chambre d'admission (sinus) et chambre de chasse (infundibulum)
- Trabéculations apicales marquées
- Paroi libre mince :
  - ✓ Compliance > VG : fonction diastolique « tolérante »
  - ✓ Contractilité < VG : fonction systolique « sensible » aux conditions de charge (post-charge +++)
- Ejection selon le mode d'un soufflet & interaction avec le VG
- Contraction de l'infundibulum difficile à explorer.

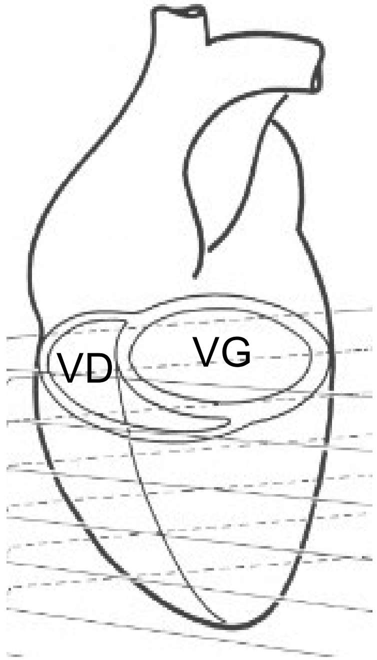
# Ventricule droit : anatomie complexe

- OD connectée aux veines caves : éjection du VD directement dépendant du retour veineux
- Forme de soufflet, enroulé autour du VG ; mesure des volumes non modélisable (recours à la 3D)
- Fibres longitudinales développées ; contraction complexe (rôle de l’infundibulum).



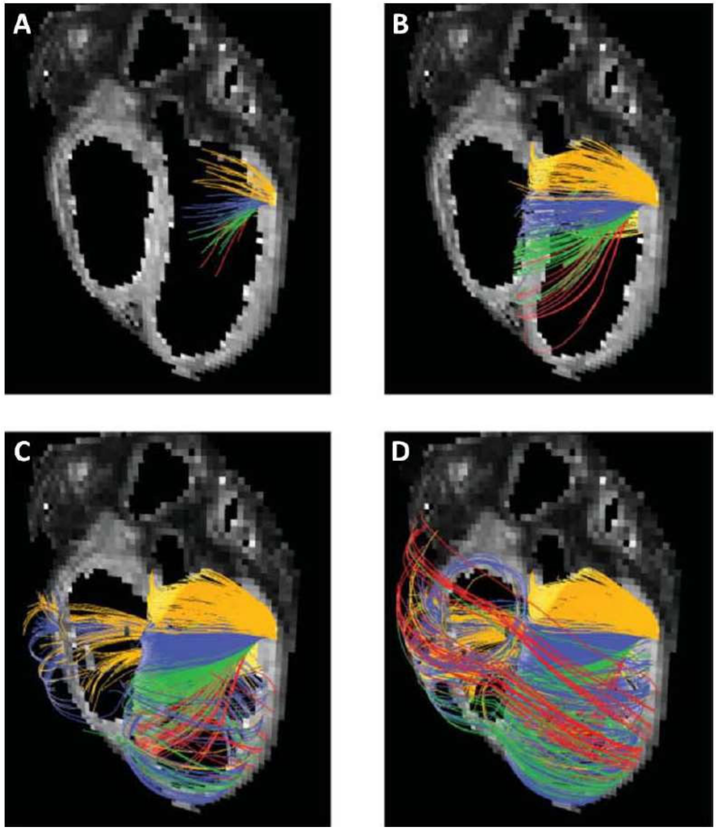



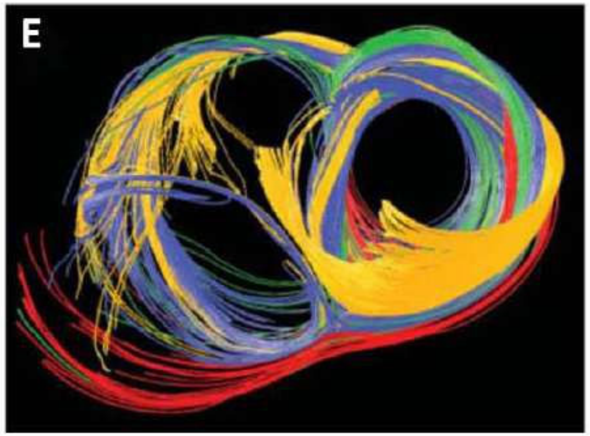





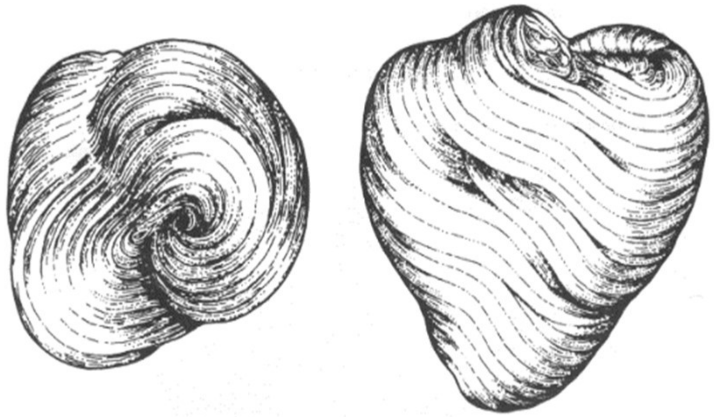

*Sanz J et al. JACC 2019*

# Ventricule droit : interdépendance avec le VG



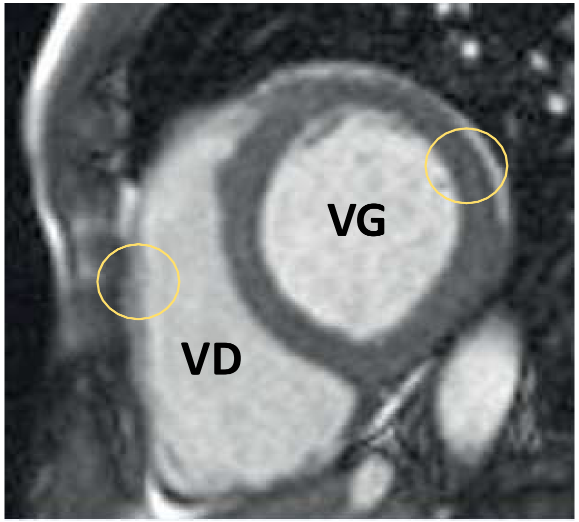

*Friedberg MK et al. Circulation 2014*

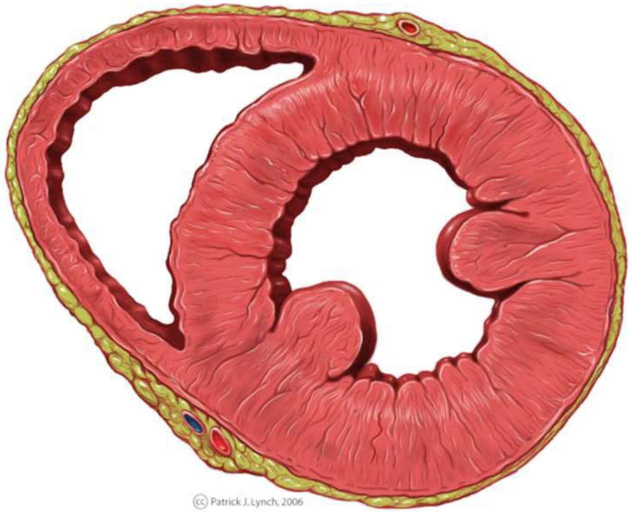


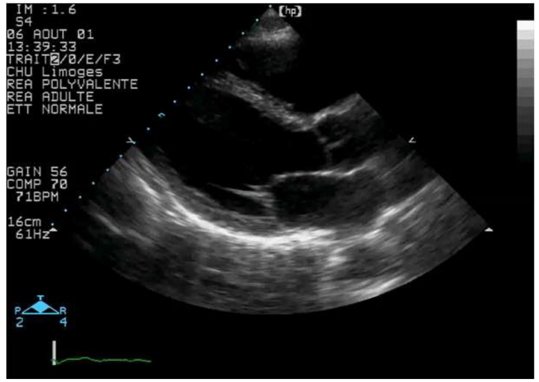
*Streeter 1957*

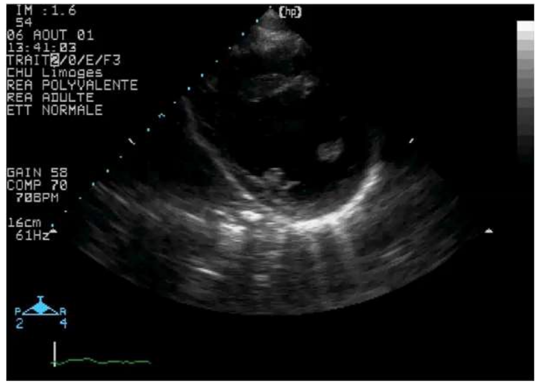
- L'éjection VD dépend de la fonction systolique VG (fibres communes)
- Interdépendance avec VG : septum interventriculaire commun.

# Ventricule droit : paroi libre fine





- Rôle du VD : éjecter la totalité du débit sanguin dans le système artériel pulmonaire en maintenant une POD basse pour faciliter le retour veineux
- Paroi libre fine adaptée aux RVP basses.

GUIDELINES AND STANDARDS

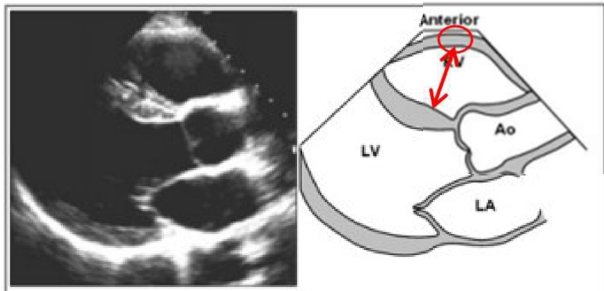
# Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

## Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography

Lawrence G. Rudski, MD, FASE, Chair, Wyman W. Lai, MD, MPH, FASE, Jonathan Afilalo, MD, Msc, Lanqi Hua, RDCS, FASE, Mark D. Handschumacher, BSc, Krishnaswamy Chandrasekaran, MD, FASE, Scott D. Solomon, MD, Eric K. Louie, MD, and Nelson B. Schiller, MD, *Montreal, Quebec, Canada; New York, New York; Boston, Massachusetts; Phoenix, Arizona; London, United Kingdom; San Francisco, California*

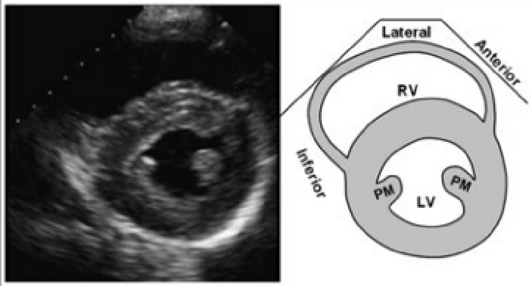
(J Am Soc Echocardiogr 2010;23:685-713.)

# VD : vues parasternales




Parasternal long-axis of RV anterior wall

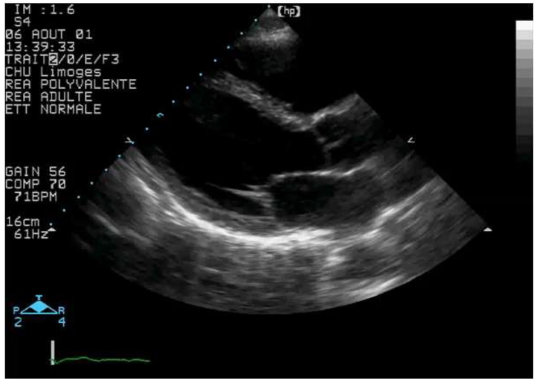
- Used for measurement of RV enlargement, RV wall thickness and the RVOT dimension by 2D.
- View is highly variable depending on transducer angulation and the rib interspace position from which it was obtained. Therefore it should not be the sole view to evaluate RVOT size.

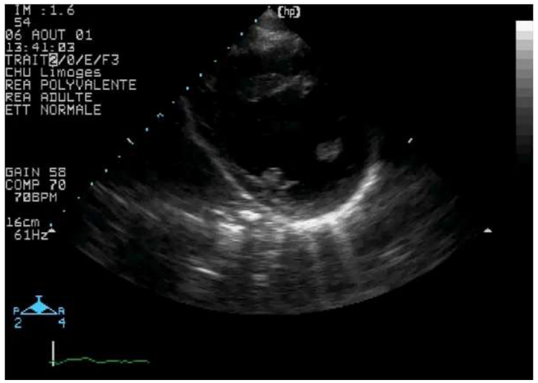



Parasternal RV short-axis at papillary muscle (PM) level

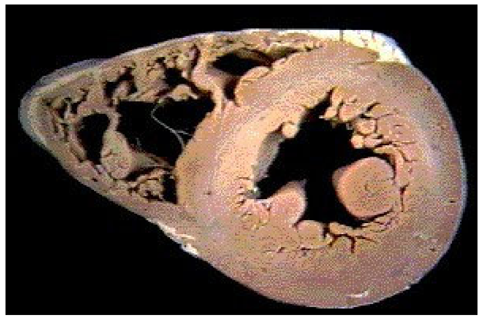
- Mid-level of anterior, inferior and lateral RV walls are shown in this view.
- A crescent shape of RV is well appreciated in this view.
- Septal flattening in systole or diastole from RV volume or pressure overload is also clearly seen in this view.
- Valuable for initial assessment of RV size, but cannot be used for assessment of RV systolic function due to the asymmetric nature of RV contraction.

*J Am Soc Echocardiogr 2010 ; 12 : 685-713*

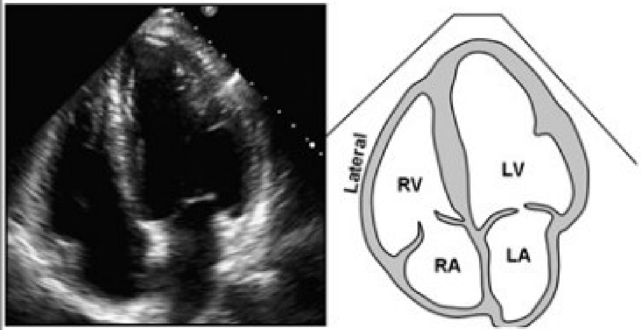
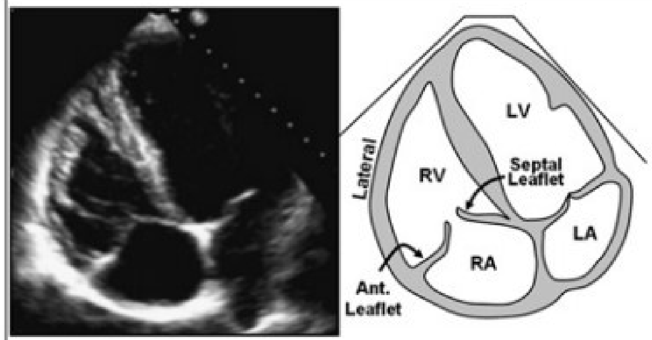


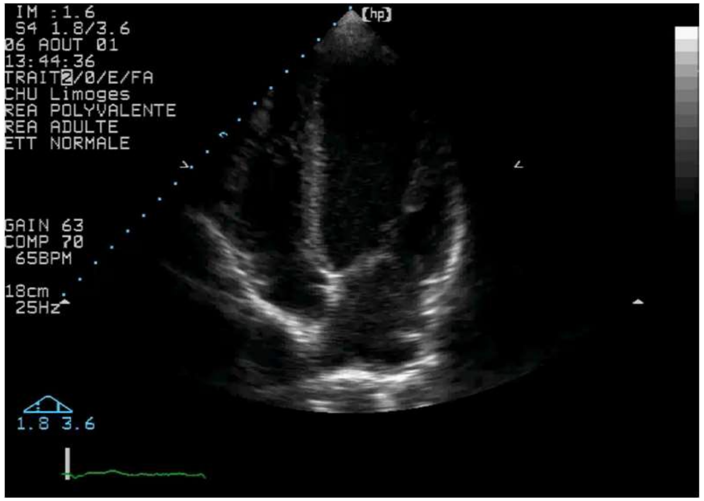





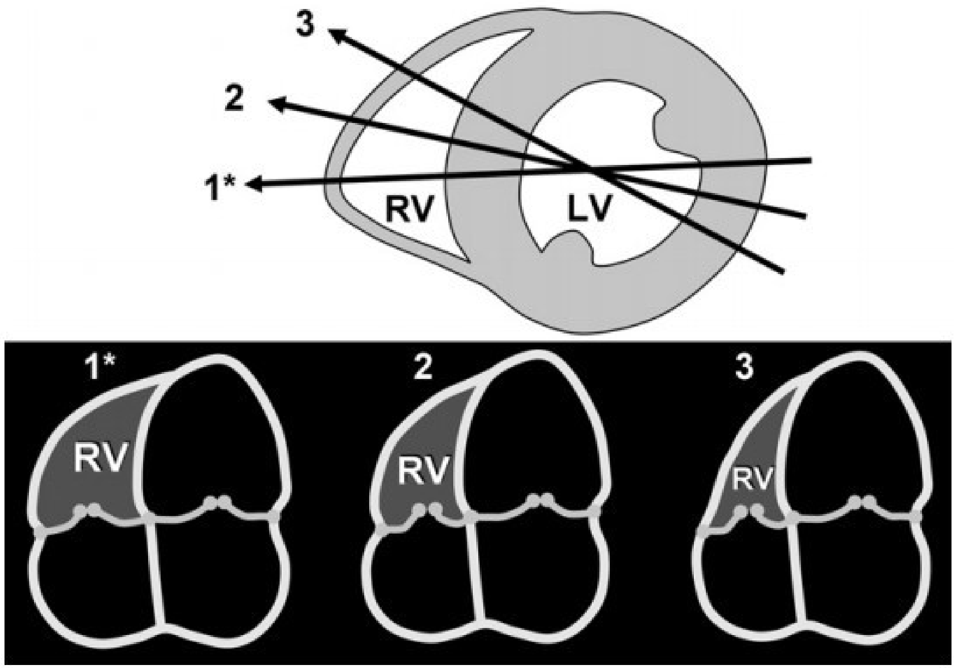


# VD : vue apicale 4 cavités

| | |
|---|---|
| <br>Apical 4-chamber | ▪ Useful view for demonstrating RV/RA size, shape and function.<br>▪ Used to measure RV maximal long-axis distance, minor distances at base and mid-level, RV area and RV fractional area change. RA major and minor axis dimensions, RA area and volume are commonly measured here.<br>▪ RV inflow, TR jet by Doppler, tricuspid annulus excursion by M-mode and RV strain by tissue Doppler are also commonly assessed in this view.<br>▪ TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam. |
| <br>RV focused apical 4-chamber | Recommended alternative to Apical 4-chamber to measure RV minor dimension in basal segment of the RV.<br>▪ Useful view for demonstrating RV/RA size, shape and function, with enhanced visualization of the RV free wall.<br>▪ TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam. |



# Incidence de l'angle de coupe sur le rapport des surfaces télédiastoliques VD/VG



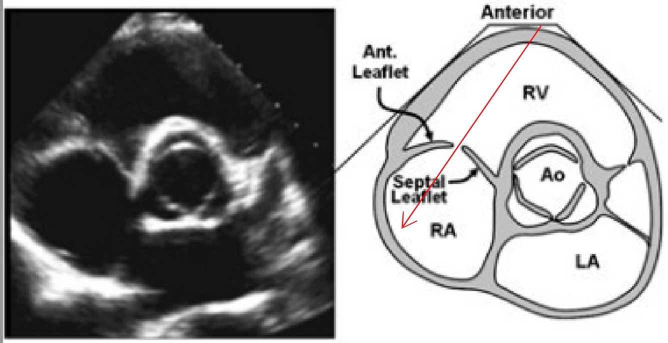
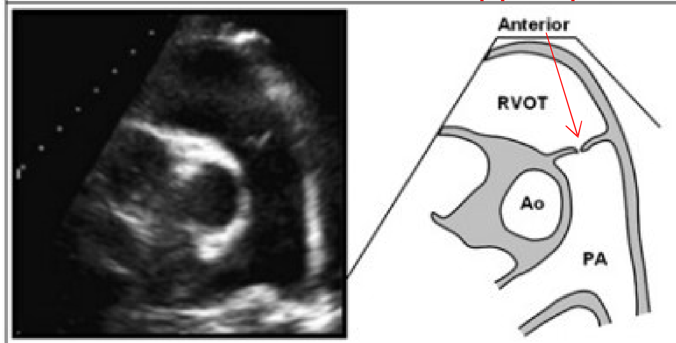

1* : coupe recommandée
2,3 : risque de sous-estimation

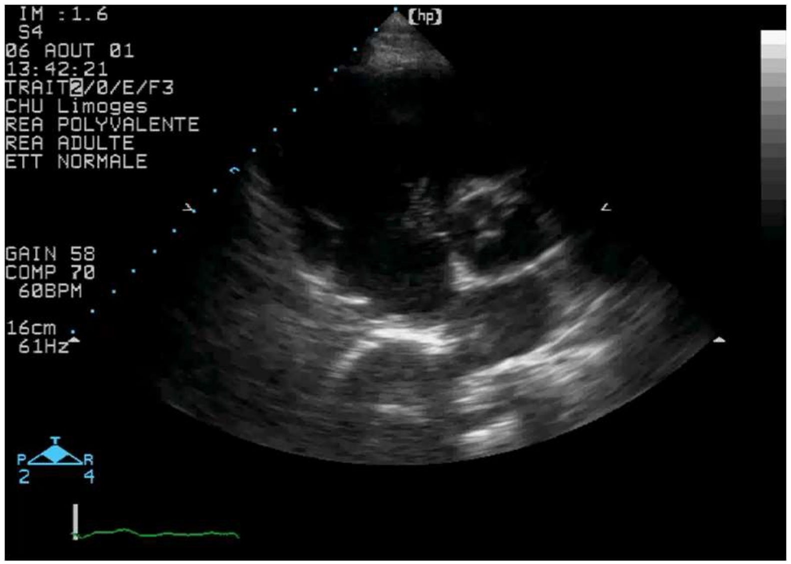
Anatomie

Etude morphologique

# VD et voie pulmonaire : vues parasternales petit axe de la base

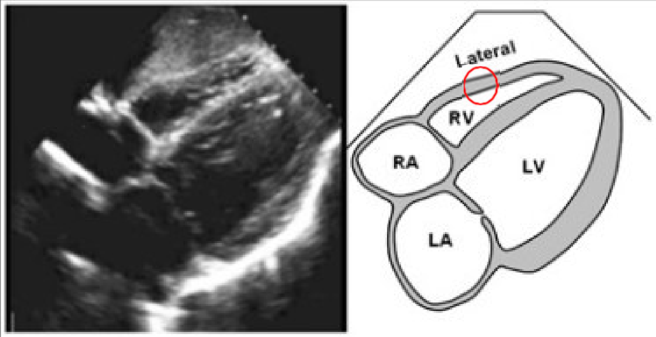
Doppler continu

| | |
|---|---|
| <br>Parasternal short-axis of basal RV | ▪ Shows the basal anterior RV wall, RVOT, tricuspid valve, pulmonary valve and RA.<br>▪ Normally used to measure RVOT dimension in diastole.<br>▪ TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.<br>▪ Used to assess the interatrial septum for shunts (particularly patent foramen ovale flow just posterior to the aortic root |
| Doppler pulsé<br><br>Parasternal short-axis of bifurcation of the PA | ▪ Used to assess the pulmonary valve, pulmonary artery and its branches.<br>▪ Used for measuring pulmonary annulus dimension, pulmonary artery size and for Doppler measurement of the infundibulum, pulmonary valve and pulmonary artery.<br>▪ Proximal and distal RVOT segments are also visible. |



# VD et voie pulmonaire : vues sous-costales (1)

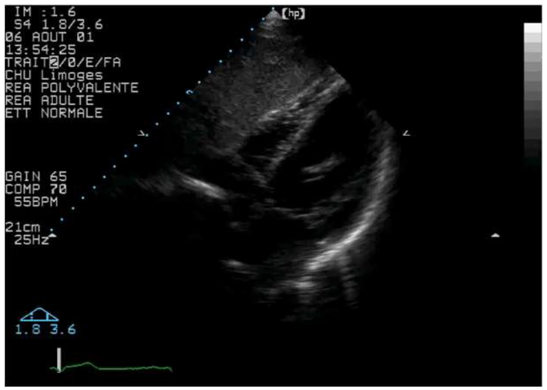
Nle < 5 mm (télédiastole)

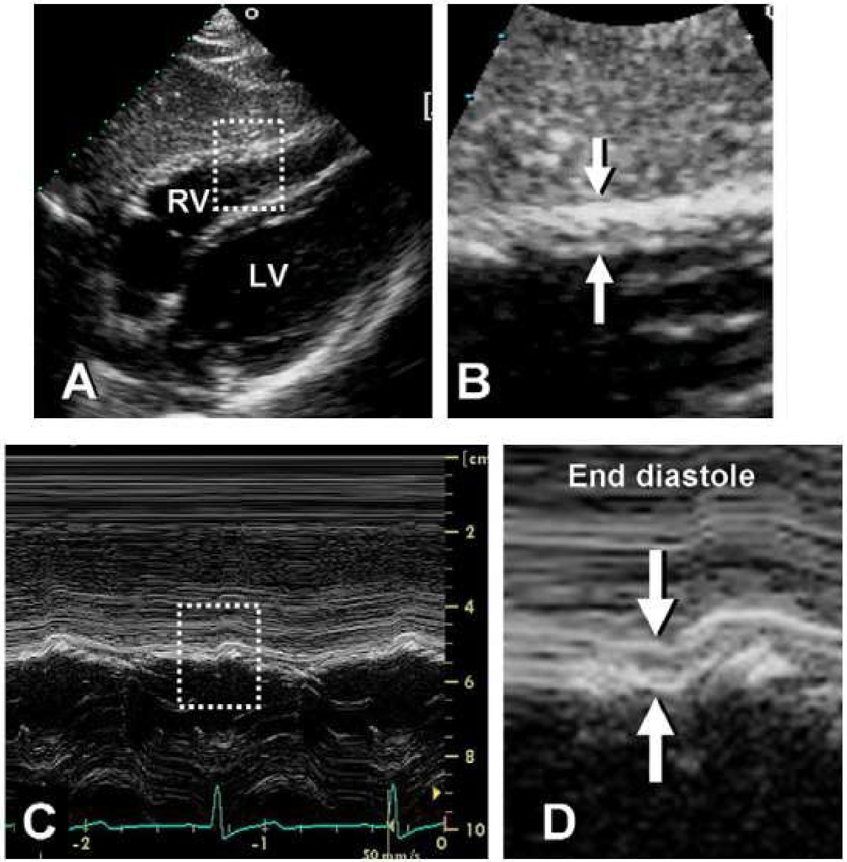



RV subcostal 4-chamber

- The RV wall thickness is best measured in this view.
- It is useful for evaluation of the RV/RA wall inversion/collapse in diagnosing patients with cardiac tamponade.
- ASD and PFO are often best shown in this view with 2D and color Doppler.
- Used to visualize but not quantify RV/RA sizes due to its foreshortened and oblique angle.
- TR jet parameters can be measured in this view provided the TR jet is parallel to the U/S beam.

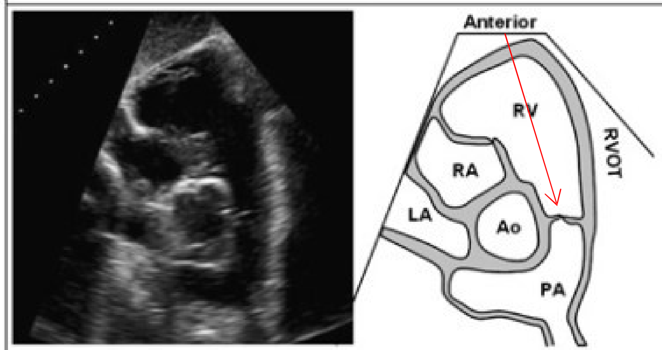
Doppler pulsé



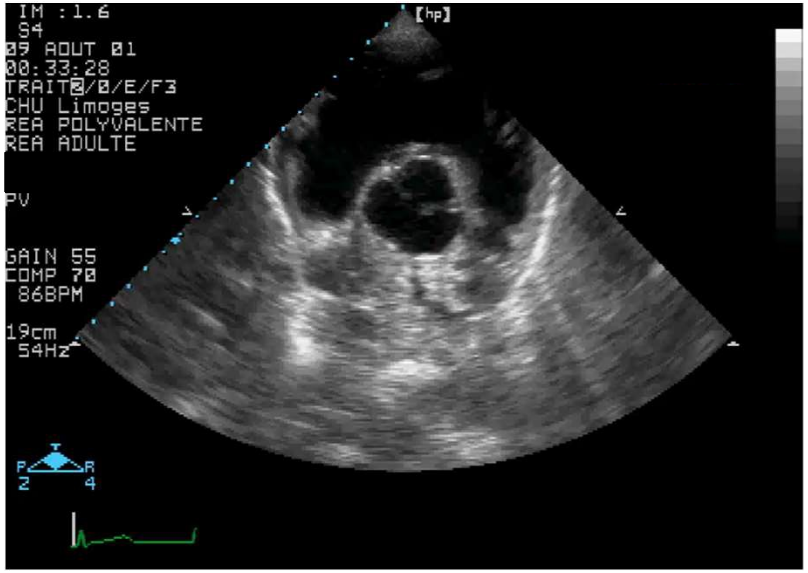
# VD et voie pulmonaire : vues sous-costales (2)

Doppler pulsé




Subcostal short-axis of basal RV

- Base of the RV wall including RV inflow, RV outflow, pulmonary valve, pulmonary artery and its branches are well visualized.
- RVOT dimension can also be measured in this view.
- Used for Doppler measurement of the infundibulum, pulmonary valve and pulmonary artery



# Vue sous-costale de la VCI

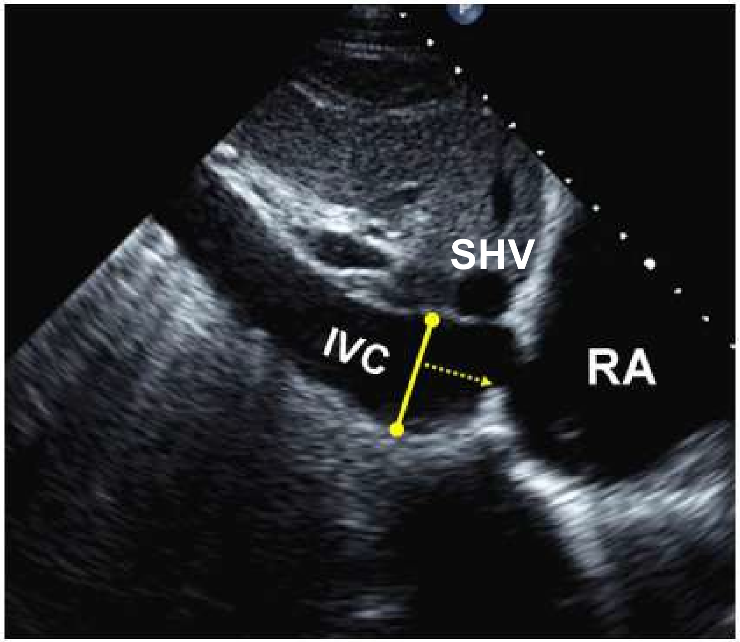
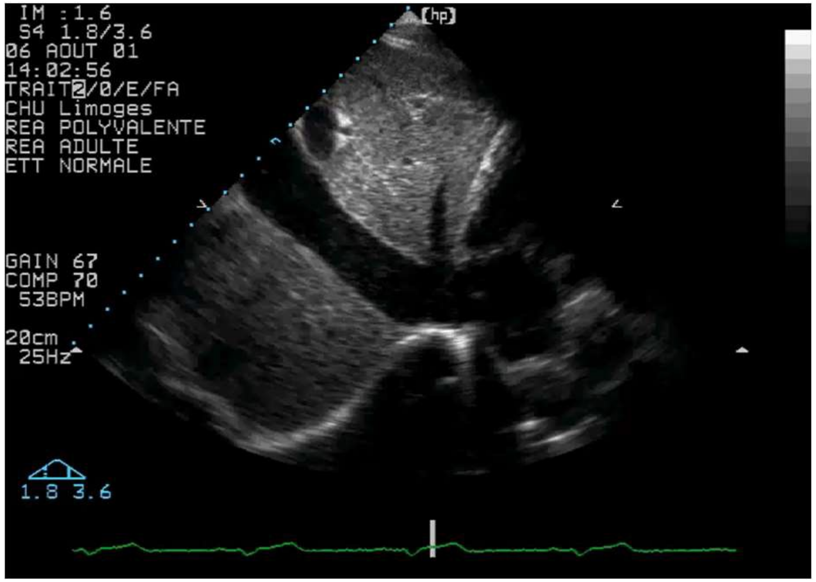


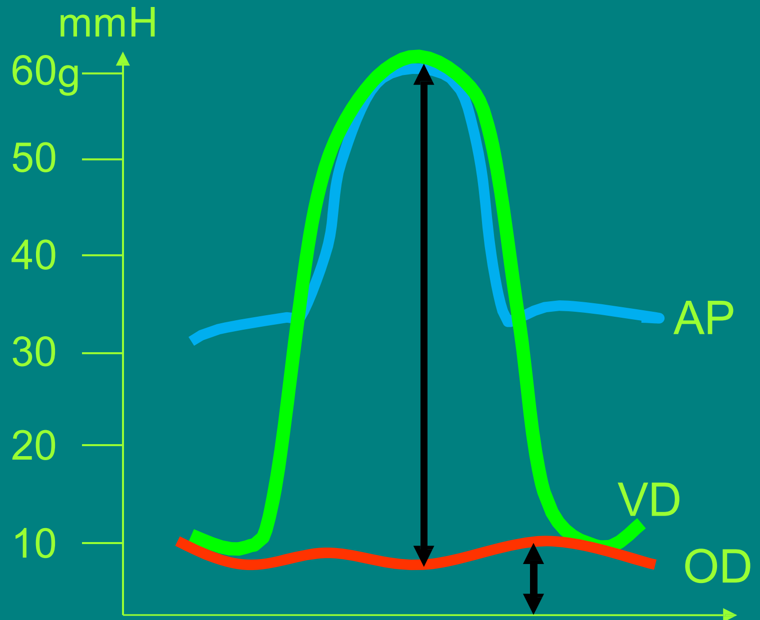

Figure 4 Inferior vena cava (IVC) view. Measurement of the IVC. The diameter *(solid line)* is measured perpendicular to the long axis of the IVC at end-expiration, just proximal to the junction of the hepatic veins that lie approximately 0.5 to 3.0 cm proximal to the ostium of the right atrium (RA).

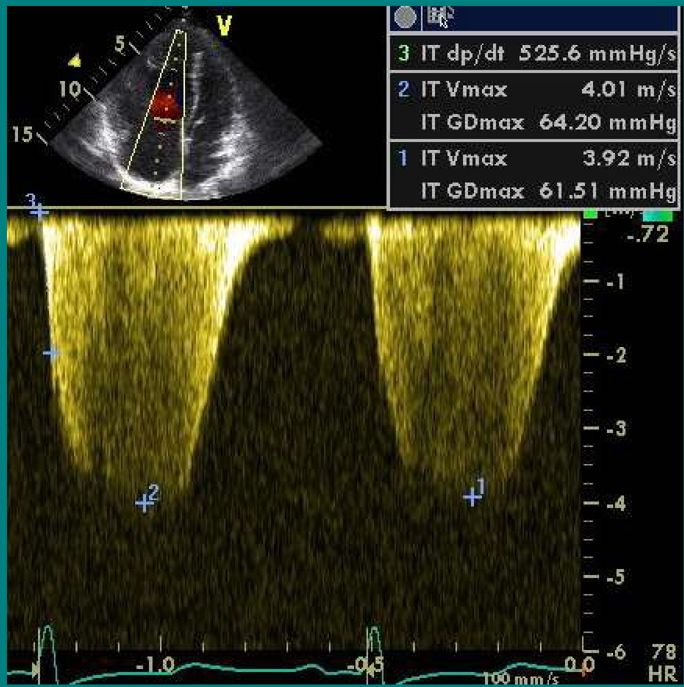


# Etude hémodynamique :
# *VD et voie pulmonaire*

- Doppler spectral (pulsé et continu)
- Utiliser différentes vues pour un alignement optimal du tir Doppler
- Estimation de la pression artérielle pulmonaire (PAP)
- Estimation du volume d'éjection systolique du VD
- Retentissement d'une insuffisance VD sur la circulation veineuse systémique.

# Evaluation de la PAPs



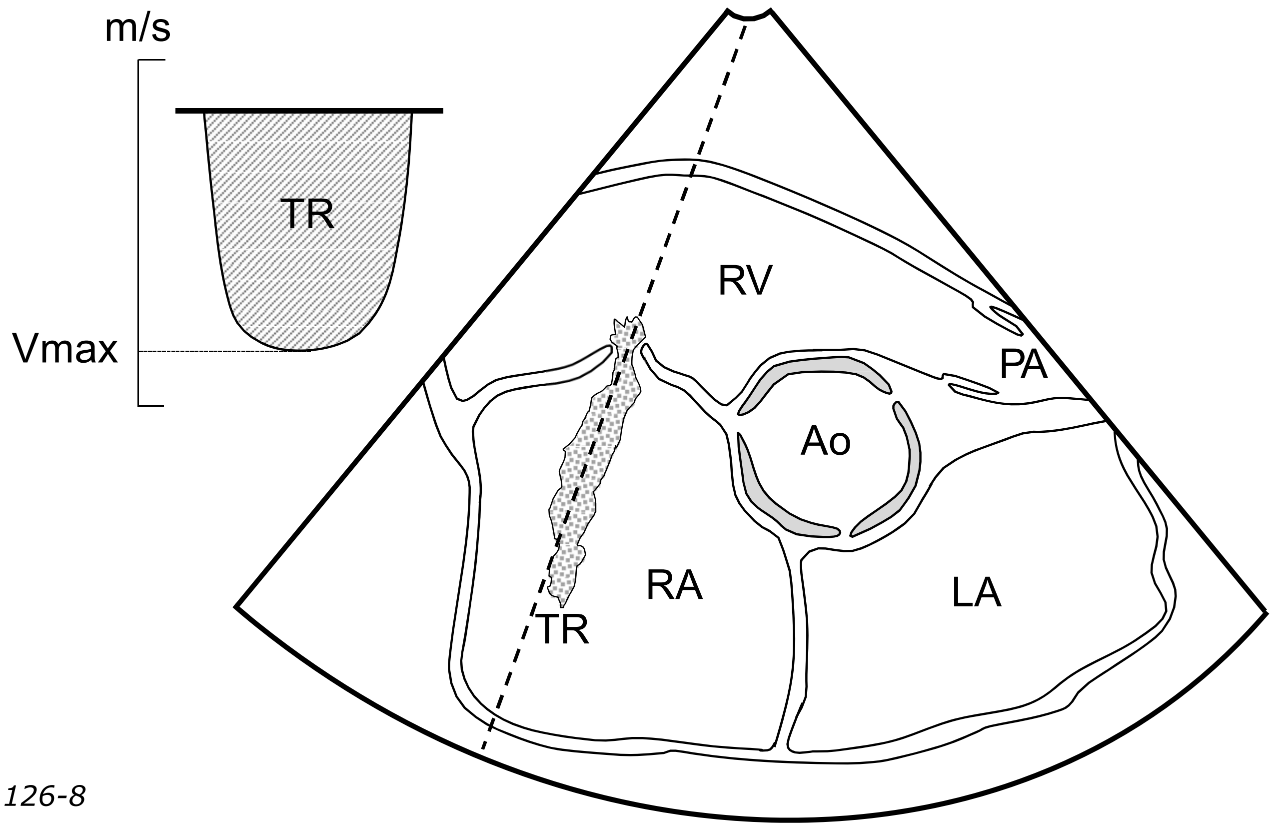

- Equation de Bernoulli : **$\Delta P = 4\ V^2$**

  (PVD syst - POD syst = 4 Vmax $IT^2$, ou PAP syst - POD syst = 4 Vmax $IT^2$)

- En l'absence de sténose pulmonaire.

# Assessment of Pulmonary Arterial Pressure Using Critical Care Echocardiography: Dealing With the Yin and the Yang?*

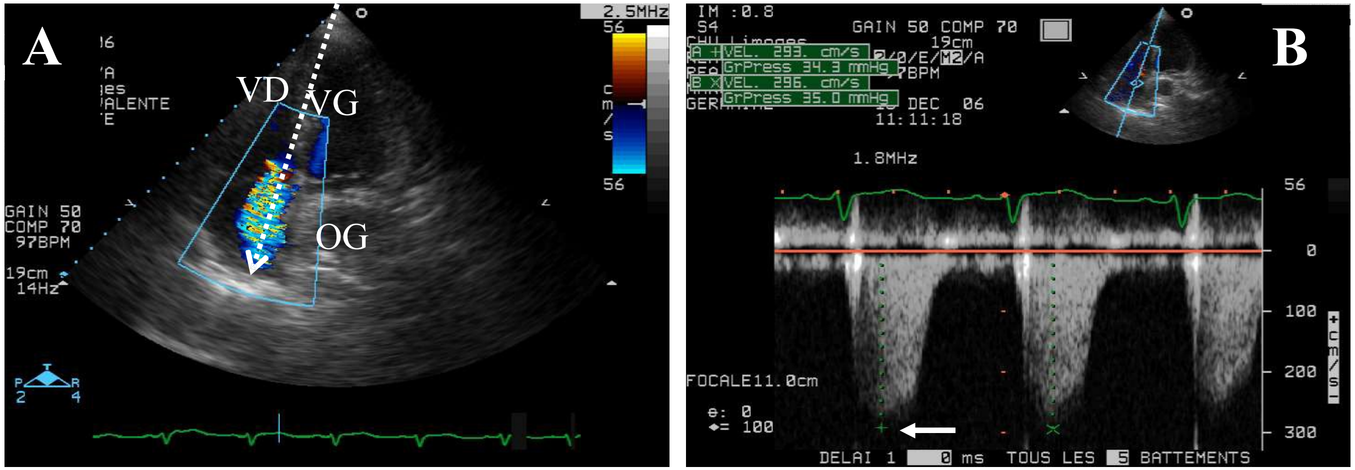
**Philippe Vignon, MD, PhD**
Medical-Surgical Intensive Care Unit,
and Inserm CIC 1435
Dupuytren Teaching Hospital; and
University of Limoges
Limoges, France




*Crit Care Med 2019 ; 47 : 126-8*

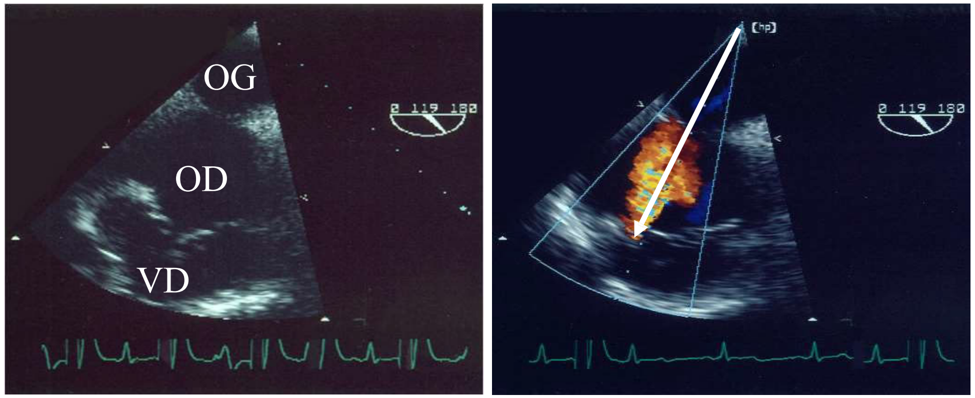
# Evaluation de la PAPs

ETT




$PAPs \approx 4 \cdot (V_{max}\ IT)^2 + POD$

ETO




Typiquement :
40 à 60°

Anatomie

Etude morphologique

Etude hémodynamique

# Evaluation de la PAPs

**TABLE 1. Technical Prerequisites and Potential Limitations of Advanced Critical Care Echocardiography for Quantitative Estimation of Pulmonary Artery Pressure**

| Technical Prerequisites for Each Successive Step | Potential Limitations of Critical Care Echocardiography |
|---|---|
| Adequate acoustic windows[a] | Feasibility in the targeted population (e.g., chronic lung diseases) and in the ICU setting (e.g., dressings, mechanical ventilation with PEEP, supine position) |
| Identifiable TR using color Doppler flow mapping | No correlation between TR jet area and right atrioventricular pressure gradient<br>The absence of TR fails to exclude pulmonary artery hypertension |
| High-quality continuous-wave Doppler signal with clear delineation of TR envelope | Inadequate alignment of Doppler beam with TR jet leading to underestimation of maximal velocity, hence peak RV systolic pressure |
| Well-identified TR peak velocity | Any measurement error is squared, leading to even higher imprecision of peak RV systolic pressure estimate |
| Multiple[b] measurements evenly performed throughout the respiratory cycle | Confounding effects of heart-lung interactions, especially in ventilated patients with high PEEP levels |
| Identification of potential sources of inaccuracy of simplified Bernouilli's equation[c] | Inaccurate quantitative estimation of pulmonary artery pressure due to imperfect transformation of potential to kinetic energy |
| Invasive measurement of CVP (equivalent to right atrial pressure)[d] | Inaccurate estimation of CVP using the size and respirophasic variations of inferior vena cava[e] |

*Crit Care Med 2019 ; 47 : 126-8*

Anatomie

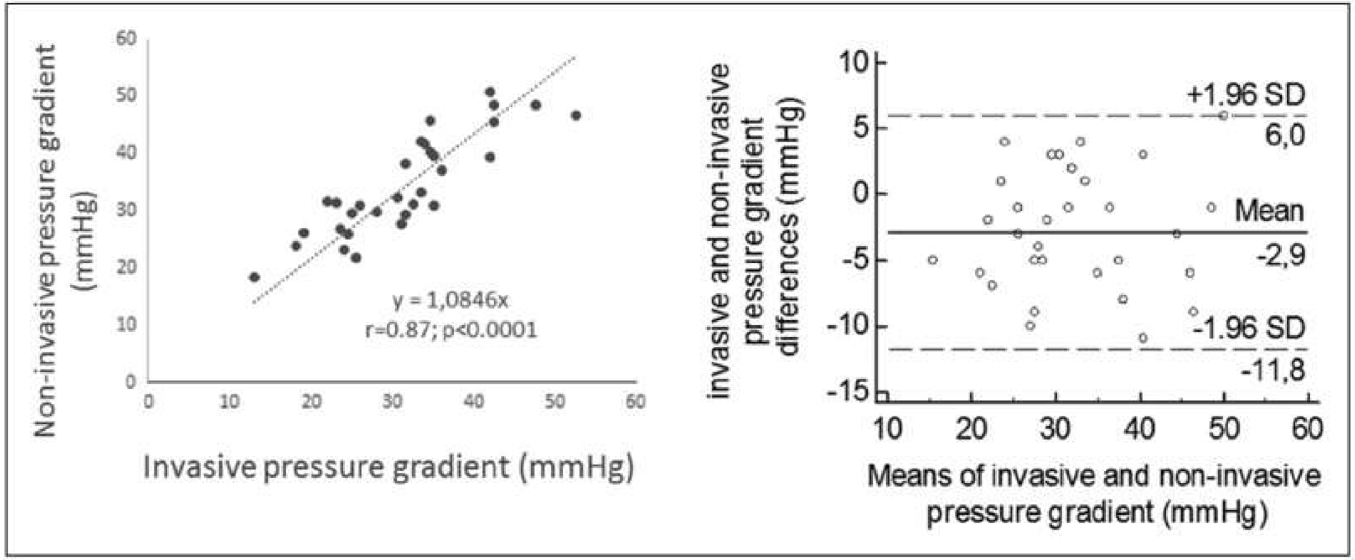
Etude morphologique

**Etude hémodynamique**

# Evaluation du gradient de pression OD-VD

## Reassessment of the Accuracy of Cardiac Doppler Pulmonary Artery Pressure Measurements in Ventilated ICU Patients: A Simultaneous Doppler-Catheterization Study*

Pablo Mercado, MD[1]; Julien Maizel, MD, PhD[1,2]; Christophe Beyls, MD[1]; Loay Kontar, MD[1];
Sam Orde, MD[3]; Stephen Huang, MD, PhD[3]; Anthony McLean, MD, PhD[3];
Christophe Tribouilloy, MD, PhD[1,2]; Michel Slama, MD, PhD[1,2]




*Crit Care Med 2019 ; 47 : 41-8*

Anatomie — Etude morphologique — **Etude hémodynamique**

# Evaluation de la PVC / POD

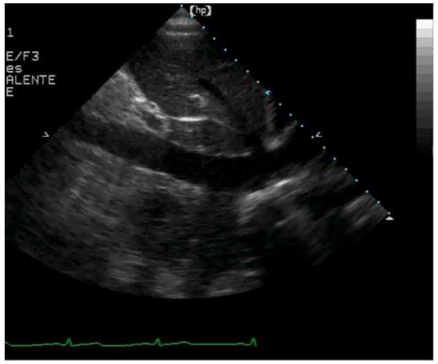
Reappraisal of the Use of Inferior Vena Cava for Estimating Right Atrial Pressure

J. Matthew Brennan, MD, John E. Blair, MD, Sascha Goonewardena, MD, Adam Ronan, MD, Dipak Shah, MD, Samip Vasaiwala, MD, James N. Kirkpatrick, MD, and Kirk T. Spencer, MD, *Chicago, Illinois*

| Diamètre de la VCI | Variations respiratoires du diamètre de la VCI en VENTILATION SPONTANEE | POD prédite |
|---|---|---|
| < 20 mm | Diminution inspiratoire > 50% | 5 mmHg |
| | Diminution inspiratoire < 50% | 10 mmHg |
| > 20 mm | Diminution inspiratoire > 50% | 15 mmHg |
| | Diminution inspiratoire < 50% | 20 mmHg |

*Brennan JM et al. J Am Soc Echocardiogr 2007; 20: 857-61*

**PVC : 5 mmHg**



**PVC : 18 mmHg**

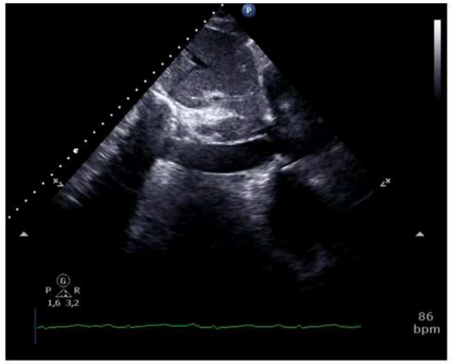



**Table 3** Estimation of RA pressure on the basis of IVC diameter and collapse

| Variable | Normal (0-5 [3] mm Hg) | Intermediate (5-10 [8] mm Hg) | | High (15 mm Hg) |
|---|---|---|---|---|
| IVC diameter | ≤2.1 cm | ≤2.1 cm | >2.1 cm | >2.1 cm |
| Collapse with sniff | >50% | <50% | >50% | <50% |

*JASE 2010 ; 23 : 685-713*

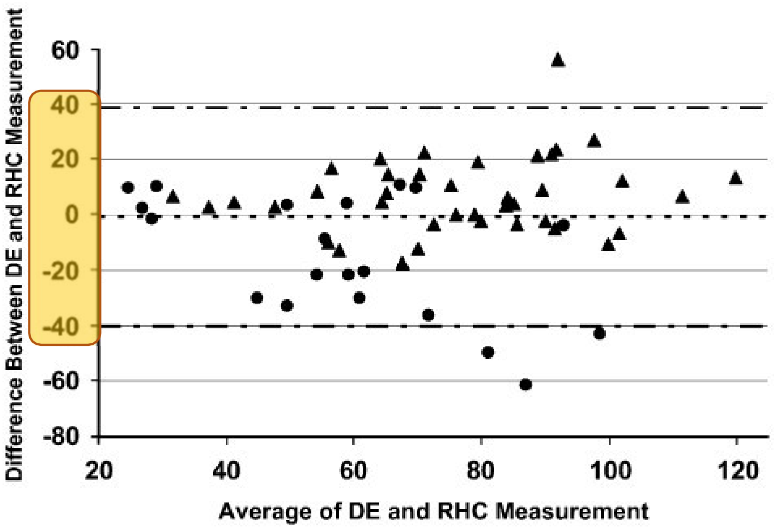
Anatomie — Etude morphologique — **Etude hémodynamique**

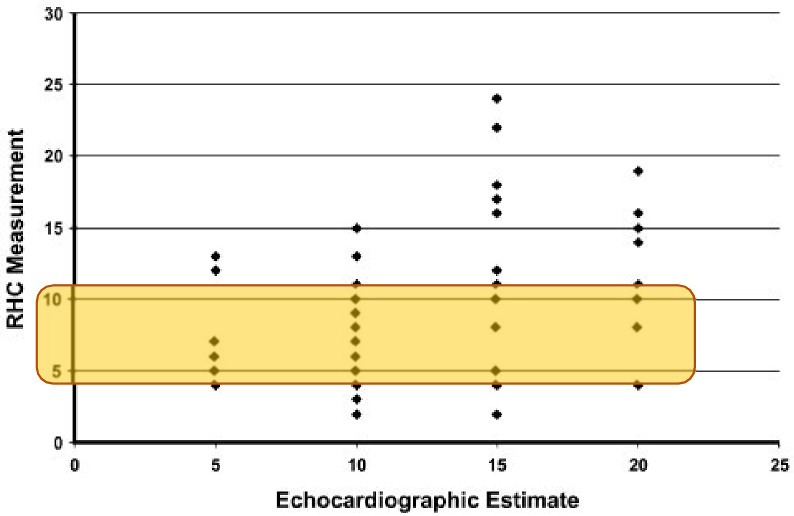
# Précision de l'évaluation de la PAPs

## Accuracy of Doppler Echocardiography in the Hemodynamic Assessment of Pulmonary Hypertension

Micah R. Fisher[1*], Paul R. Forfia[2†], Elzbieta Chamera[2], Traci Housten-Harris[1], Hunter C. Champion[2], Reda E. Girgis[1], Mary C. Corretti[2], and Paul M. Hassoun[1]

[1]Division of Pulmonary and Critical Care Medicine; [2]Division of Cardiology, Department of Medicine, Johns Hopkins University, Baltimore, Maryland



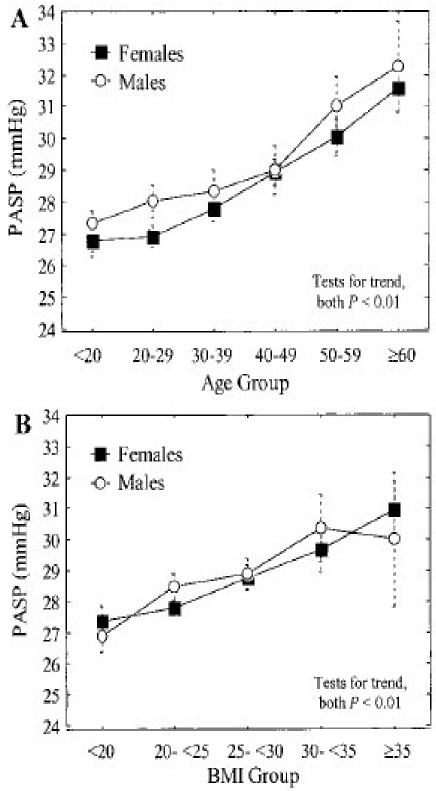

Manque de précision liée à la mauvaise évaluation PVC : la mesurer sur KTC !

Anatomie

Etude morphologique

Etude hémodynamique

# Limites de normalité de la PAPs (1)




Mc Quillan BM. Circulation 2001 ; 104 : 2797-2802

CHEST — Original Research

PULMONARY VASCULAR DISEASE

**Echocardiography of the Pulmonary Circulation and Right Ventricular Function**

**Exploring the Physiologic Spectrum in 1,480 Normal Subjects**

***Results:*** PASP and mean pulmonary artery pressure values were significantly higher in subjects aged >50 years and in those with a BMI >30 kg/m². In particular, a PASP >40 mm Hg was found in 118 subjects (8%) of those aged >50 years and in 103 (7%) of those with a BMI >30 kg/m².

**Table 4—*Significant Independent Relation of PASP in the Overall Population With Clinical Variables and Echocardiography Variables by Multivariate Analysis***

| Dependent Variable | Independent Variables | β Coefficient | *P* Value |
|---|---|---|---|
| PASP | Age | 0.41 | <.001 |
| | Male sex | 0.21 | NS |
| | BMI | 0.44 | <.001 |
| | LV E/e′ | 0.46 | <.001 |
| | LV mass index | 0.26 | NS |
| | LV stroke volume | 0.36 | <.01 |

D'Andrea A. Chest 2014 ; 145 : 1071-8

Anatomie

Etude morphologique

Etude hémodynamique

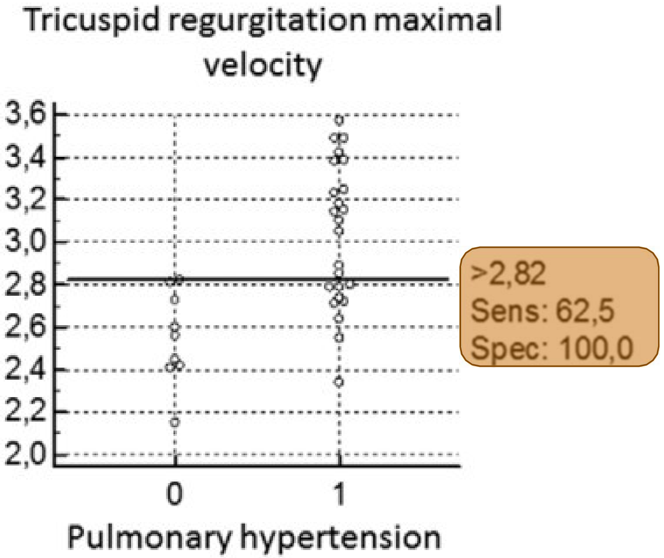
# Limites de normalité de la PAPs (2)

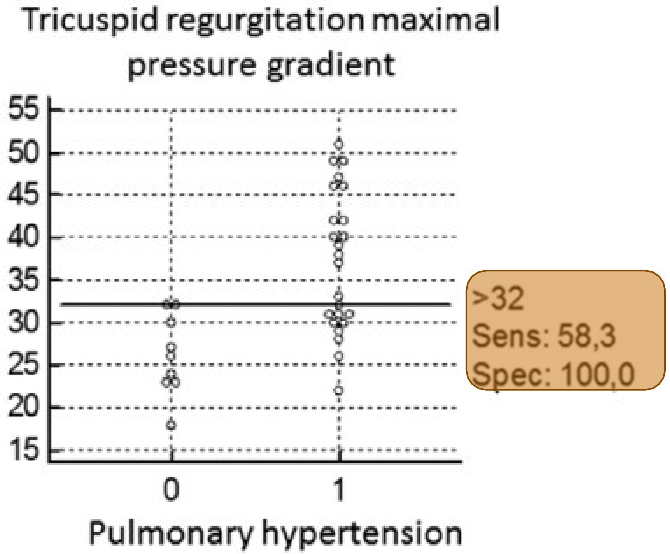
- HTAP : PAPs > 30 mmHg ou PAPm > 20 mmHg
- En fait : PAPs jusqu'à 38 mmHg (adulte normal non obèse) et 47 mmHg (adulte normal obèse)[1]

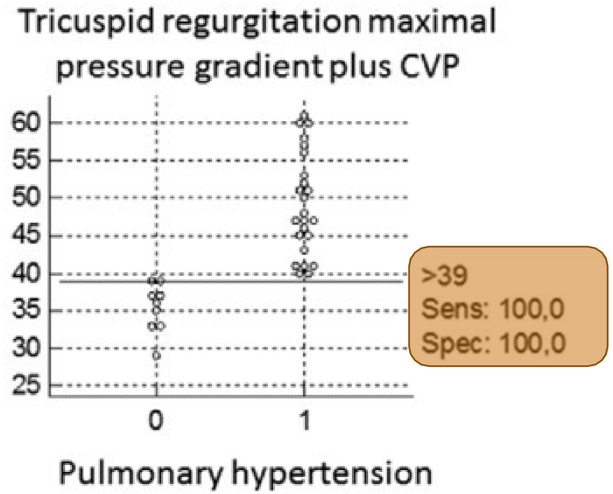
  et PAP élevée chez les hypertendus âgés[2]
- HTAP si Vmax IT > 3 m/s en l'absence d'obésité et d'HTA
- Vmax IT > 2.9 m/s : un des 4 critères de dysfonction diastolique VG.

[1] : *Abergel E et al. Am J cardiol 1996 ; 77 : 767-9*
[2] : *Finkelhor RS et al. Chest 2003 ; 123 : 711-5*

# Limites de normalité de la PAPs (3)




*Mercado P et al. Crit Care Med 2019 ; 47 : 41-8*

Anatomie

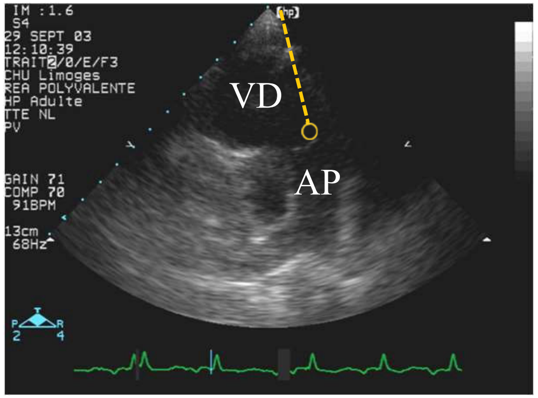
Etude morphologique

Etude hémodynamique

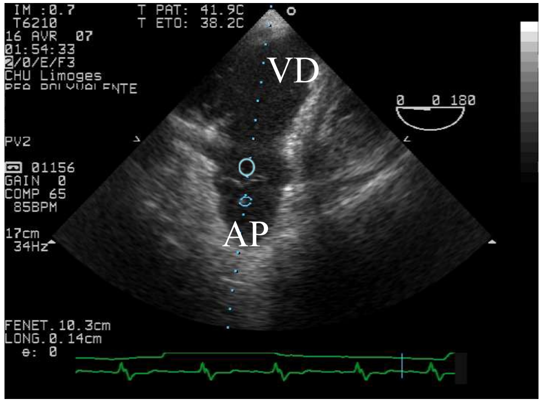
# Doppler pulmonaire

## *Doppler pulsé*

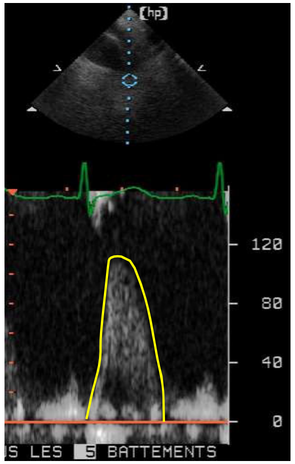
ETT




ETO

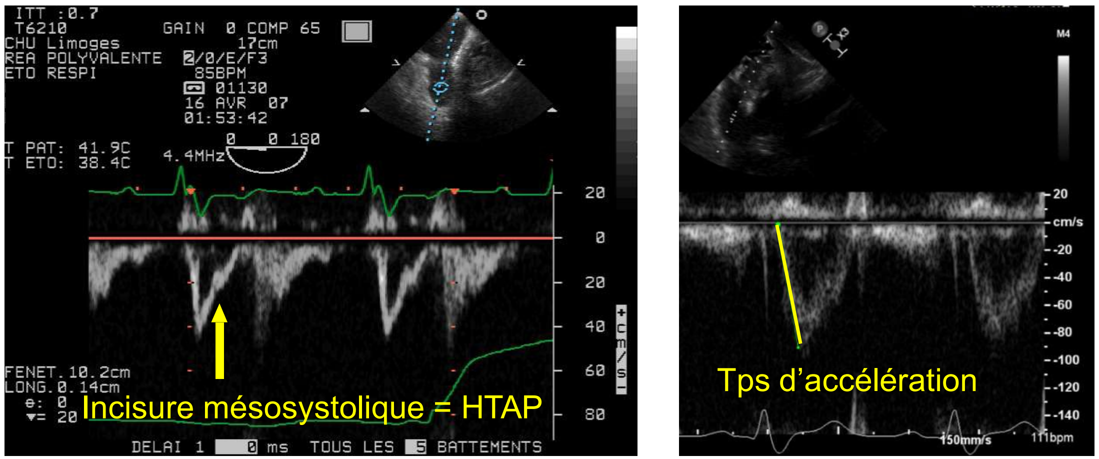



ETO base 0°



Mesure de l'ITV pulmonaire ~ volume d'éjection systolique VD

Transgastrique profonde 0°



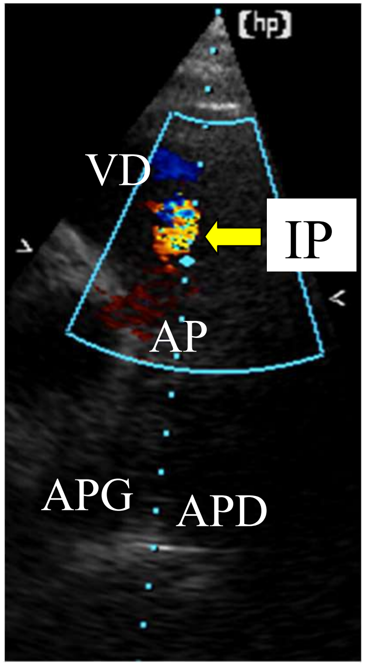

Mesure du temps d'accélération et profil de l'ITV pulmonaire

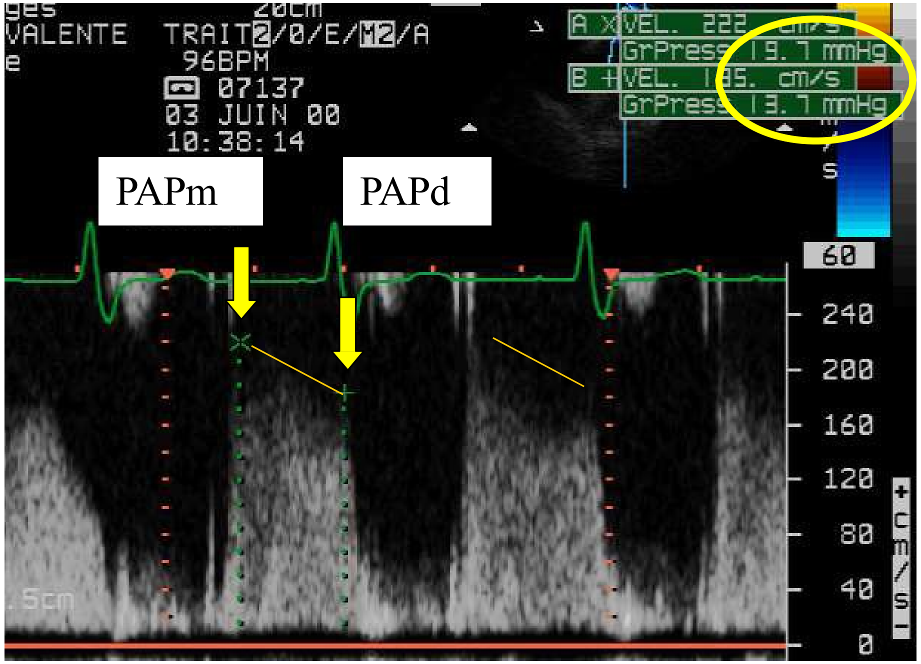
# Doppler pulmonaire

## *Doppler continu*

PAPm ~ 4 • (Vmax IP protodiastolique)² + POD

PAPd ~ 4 • (Vmax IP télédiastolique)² + POD

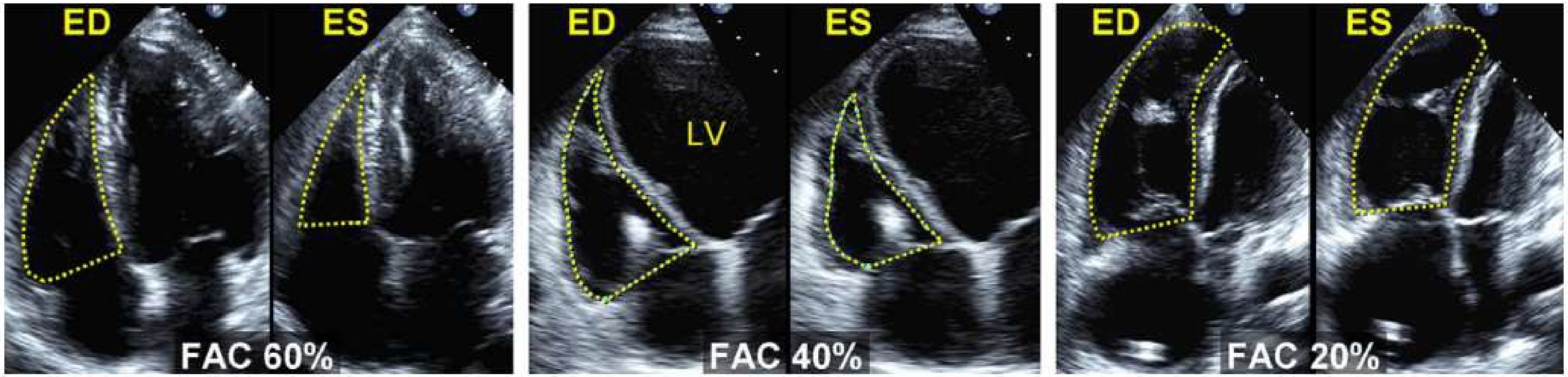



Pressions (mmHg) :

PVC = 14
PAPm = 34
PAPd = 28

# Fraction de réduction de surface du VD




Normale : 40 à 70 % (Jardin), 30 à 60% (Weyman)

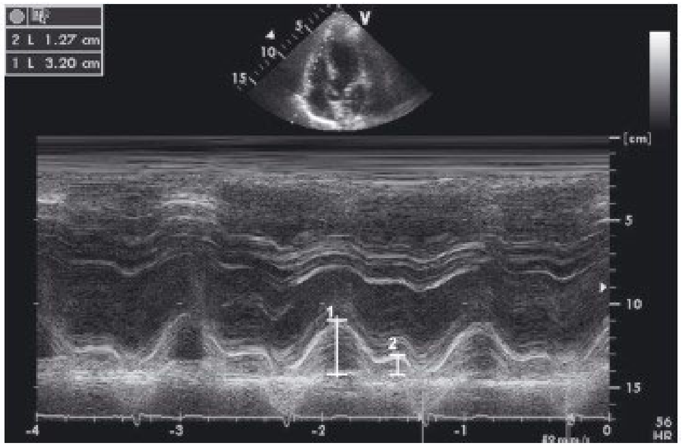
*JASE 2010 ; 23 : 685-713*

Anatomie | Etude morphologique | Etude hémodynamique | **Fonction VD**

# Fonction systolique des fibres longitudinale du VD

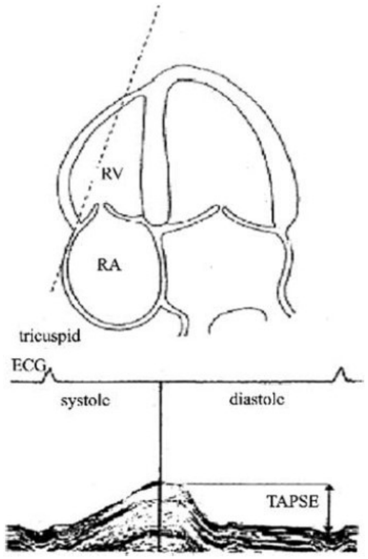
**TAPSE**

*Tricuspid Annulus Plane Systolic Excursion*

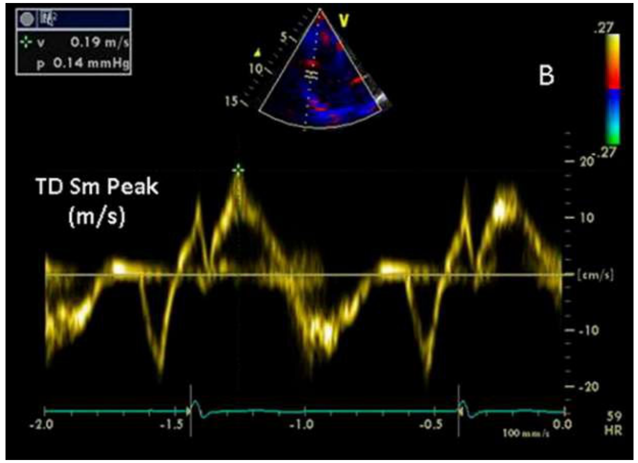



Mode TM

**Normale : 16 à 30 mm**




**Onde S'**




Doppler tissulaire pulsé

**Normale : 10 à 19 cm/s**

Anatomie

Etude morphologique

Etude hémodynamique

**Fonction VD**

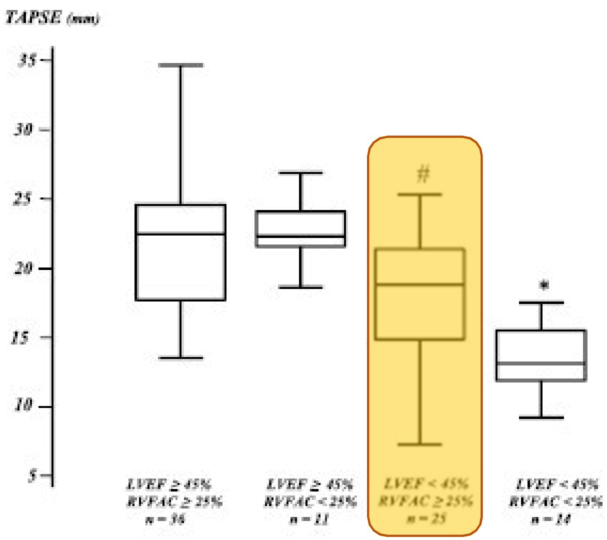
# Limites du TAPSE

Intensive Care Med (2007) 33:2143–2149
DOI 10.1007/s00134-007-0881-y

ORIGINAL

Bouchra Lamia
Jean-Louis Teboul
Xavier Monnet
Christian Richard
Denis Chemla

**Relationship between the tricuspid annular plane systolic excursion and right and left ventricular function in critically ill patients**



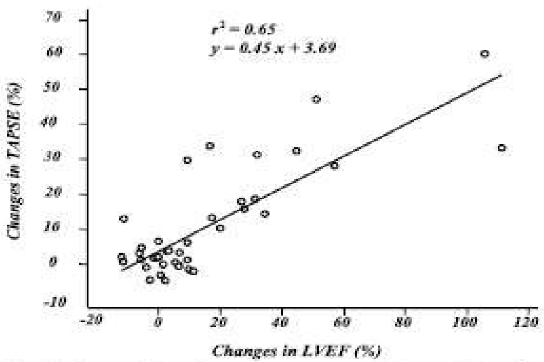




**Fig. 3** Linear relationship between changes in left ventricular ejection fraction (LVEF) and changes in tricuspid annular plane systolic excursion (TAPSE) following fluid challenge (n = 15), passive leg raising (n = 5), and dobutamine infusion (n = 20)

Vieillard-Baron et al. Crit Care (2020) 24:630
https://doi.org/10.1186/s13054-020-03345-z

Critical Care

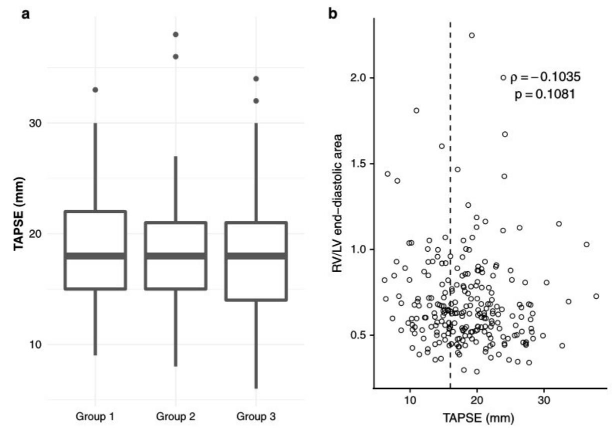
RESEARCH Open Access

**Right ventricular failure in septic shock: characterization, incidence and impact on fluid responsiveness**

Antoine Vieillard-Baron[1,2,3*], Amélie Prigent[1,2], Xavier Repessé[1], Marine Goudelin[1], Gwenaël Prat[4], Bruno Evrard[5], Cyril Charron[1], Philippe Vignon[5,6,7] and Guillaume Geri[1,2,3]

Groupe 1 : STDVD/VG < 0.6
Groupe 2 : STDVD/VG ≥ 0.6 et PVC < 8 mmHg
Groupe 3 : STDVD/VG ≥ 0.6 et PVC ≥ 8 mmHg.

282 patients ventilés en choc septique



# Valeurs normales

GUIDELINES AND STANDARDS

Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography
Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography

Lawrence G. Rudski, MD, FASE, Chair, Wyman W. Lai, MD, MPH, FASE, Jonathan Afilalo, MD, Msc, Lanqi Hua, RDCS, FASE, Mark D. Handschumacher, BSc, Krishnaswamy Chandrasekaran, MD, FASE, Scott D. Solomon, MD, Eric K. Louie, MD, and Nelson B. Schiller, MD, *Montreal, Quebec, Canada; New York, New York; Boston, Massachusetts; Phoenix, Arizona; London, United Kingdom; San Francisco, California*

(J Am Soc Echocardiogr 2010;23:685-713.)

**Table 4** Systolic function

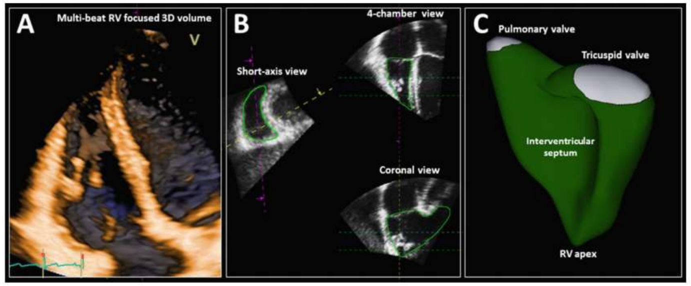
| Variable | Studies | n | LRV (95% CI) | Mean (95% CI) | URV (95% CI) |
|---|---|---|---|---|---|
| TAPSE (mm) (Figure 17) | 46 | 2320 | 16 (15-18) | 23 (22-24) | 30 (29-31) |
| Pulsed Doppler velocity at the annulus (cm/s) | 43 | 2139 | 10 (9-11) | 15 (14-15) | 19 (18-20) |
| Color Doppler velocities at the annulus (cm/s) | 5 | 281 | 6 (5-7) | 10 (9-10) | 14 (12-15) |
| Pulsed Doppler MPI (Figures 16 and 18) | 17 | 686 | 0.15 (0.10-0.20) | 0.28 (0.24-0.32) | 0.40 (0.35-0.45) |
| Tissue Doppler MPI (Figure 18) | 8 | 590 | 0.24 (0.16-0.32) | 0.39 (0.34-0.45) | 0.55 (0.47-0.63) |
| FAC (%) (Figure 8) | 36 | 1276 | 35 (32-38) | 49 (47-51) | 63 (60-65) |
| RV EF (%) (Figure 8) | 12 | 596 | 44 (38-50) | 58 (53-63) | 71 (66-77) |
| 3D RV EF (%) | 9 | 524 | 44 (39-49) | 57 (53-61) | 69 (65-74) |
| IVA ($m/s^2$) | 12 | 389 | 2.2 (1.4-3.0) | 3.7 (3.0-4.4) | 5.2 (4.4-5.9) |

*CI*, Confidence interval; *EF*, ejection fraction; *FAC*, fractional area change; *IVA*, isovolumic acceleration; *LRV*, lower reference value; *MPI*, myocardial performance index; *RV*, right ventricular; *TAPSE*, tricuspid annular plane systolic excursion; *3D*, three-dimensional; *URV*, upper reference value.

*J Am Soc Echocardiogr 2010 ; 12 : 685-713*

# Valeurs pathologiques

Journal of the American Society of Echocardiography
January 2015




Seulement accessible en 3D
(validé contre IRM)

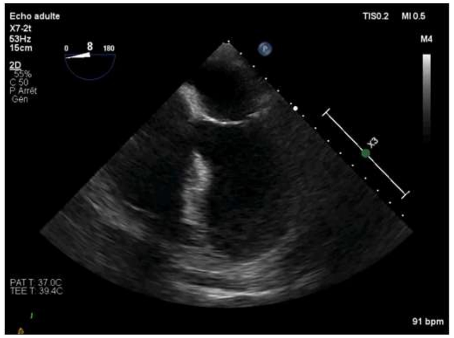
**Table 10** Normal values for parameters of RV function

| Parameter | Mean ± SD | Abnormality threshold |
|---|---|---|
| TAPSE (mm) | 24 ± 3.5 | <17 |
| Pulsed Doppler S wave (cm/sec) | 14.1 ± 2.3 | <9.5 |
| Color Doppler S wave (cm/sec) | 9.7 ± 1.85 | <6.0 |
| RV fractional area change (%) | 49 ± 7 | <35 |
| RV free wall 2D strain* (%) | −29 ± 4.5 | >−20 (<20 in magnitude with the negative sign) |
| RV 3D EF (%) | 58 ± 6.5 | <45 |
| Pulsed Doppler MPI | 0.26 ± 0.085 | >0.43 |
| Tissue Doppler MPI | 0.38 ± 0.08 | >0.54 |
| E wave deceleration time (msec) | 180 ± 31 | <119 or >242 |
| E/A | 1.4 ± 0.3 | <0.8 or >2.0 |
| e′/a′ | 1.18 ± 0.33 | <0.52 |
| e′ | 14.0 ± 3.1 | <7.8 |
| E/e′ | 4.0 ± 1.0 | >6.0 |

*MPI*, Myocardial performance index.
*Limited data; values may vary depending on vendor and software version.

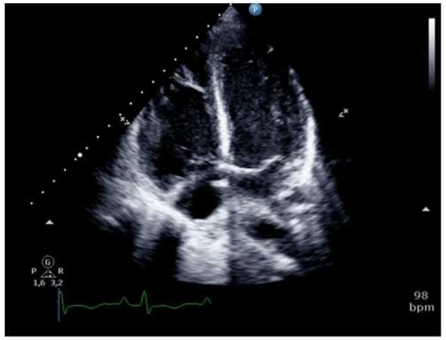
# Evolution de l'atteinte du VD (découplage VD / AP)

VD/VG : 0,7



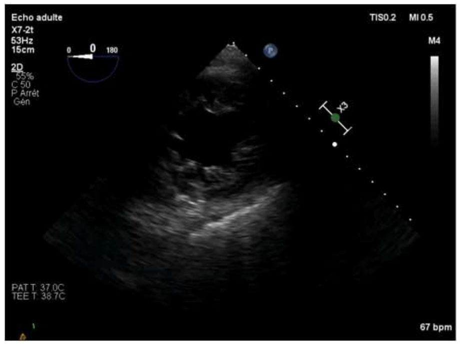
VD/VG : 0,8

VD/VG : 1,1

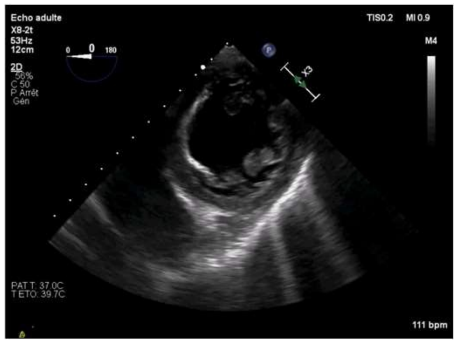


VD/VG : 1,3

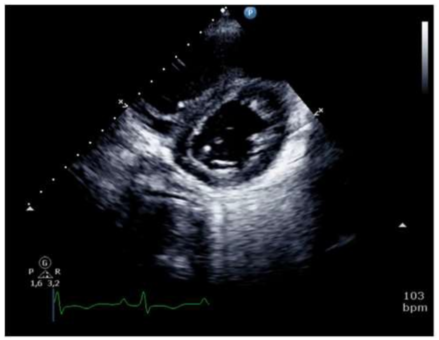
Septum normal



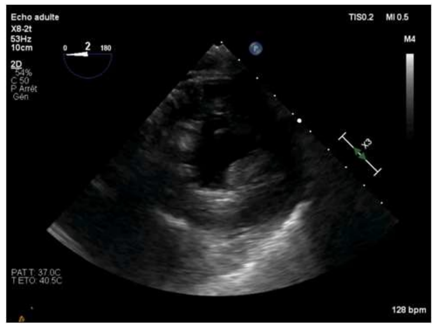
Septum grade 1



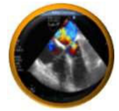
Septum grade 2



Septum grade 2



# Exploration du coeur droit et de la voie pulmonaire



- Echocardiographie : information triple (morphologie, hémodynamique et fonction systolique VD)

- Pas de modélisation géométrique simple du VD à la différence du VG

- ***Pas*** de superposition fonctionnelle avec le VG

- **Sensibilité** du VD aux conditions de charge **(post-charge).**

# Evaluation des résistances vasculaires pulmonaires

Journal of the American College of Cardiology
Vol. 41, No. 6, 2003
ISSN 0735-1097/03/$30.00
doi:10.1016/S0735-1097(02)02973-X
Published by Elsevier Science Inc.


**Pulmonary Hypertension**

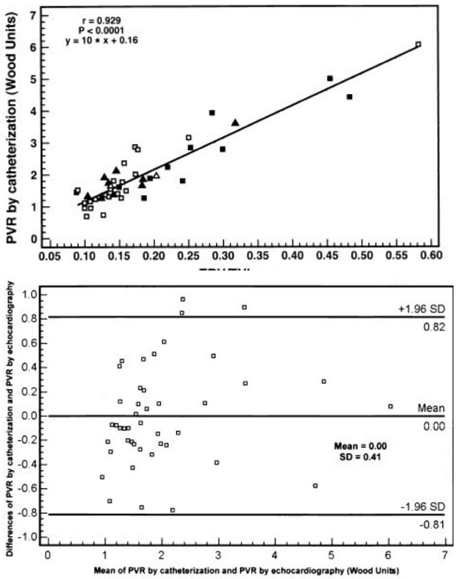
## A Simple Method for Noninvasive Estimation of Pulmonary Vascular Resistance

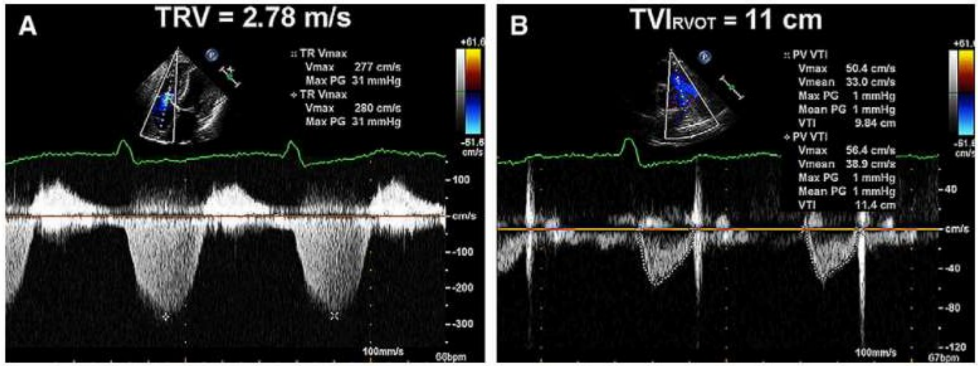
Amr E. Abbas, MD,* F. David Fortuin, MD,* Nelson B. Schiller, MD, FACC,† Christopher P. Appleton, MD, FACC,* Carlos A. Moreno, BS,* Steven J. Lester, MD, FACC*
*San Francisco, California; and Scottsdale, Arizona*

Based on our results, we propose a simplified equation for noninvasive calculation of PVR:

$$PVR(WU) = 10 \times TRV/TVI_{RVOT}$$

We also propose that in patients with increased PASP on Doppler echocardiography and $TRV/TVI_{RVOT} > 0.2$, an elevated PVR is suggested, and these patients may require further invasive workup. However, in patients with $TRV/TVI_{RVOT} < 0.2$, PVR values are likely to be normal, even in the presence of Doppler evidence of increased PASP.




- V max IT / ITV pulm > 0,20 : pathologique (= 0,25)
- RVP estimées = 10 (V max IT / ITV pulm) + 0,16 (= 2,68 UW)