Cours de science de base MMD6512

Dr André Y. Denault

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Co-Directeur de la recherche et du programme de fellowship en échographie ciblée du DAMD
Institut de Cardiologie de Montréal

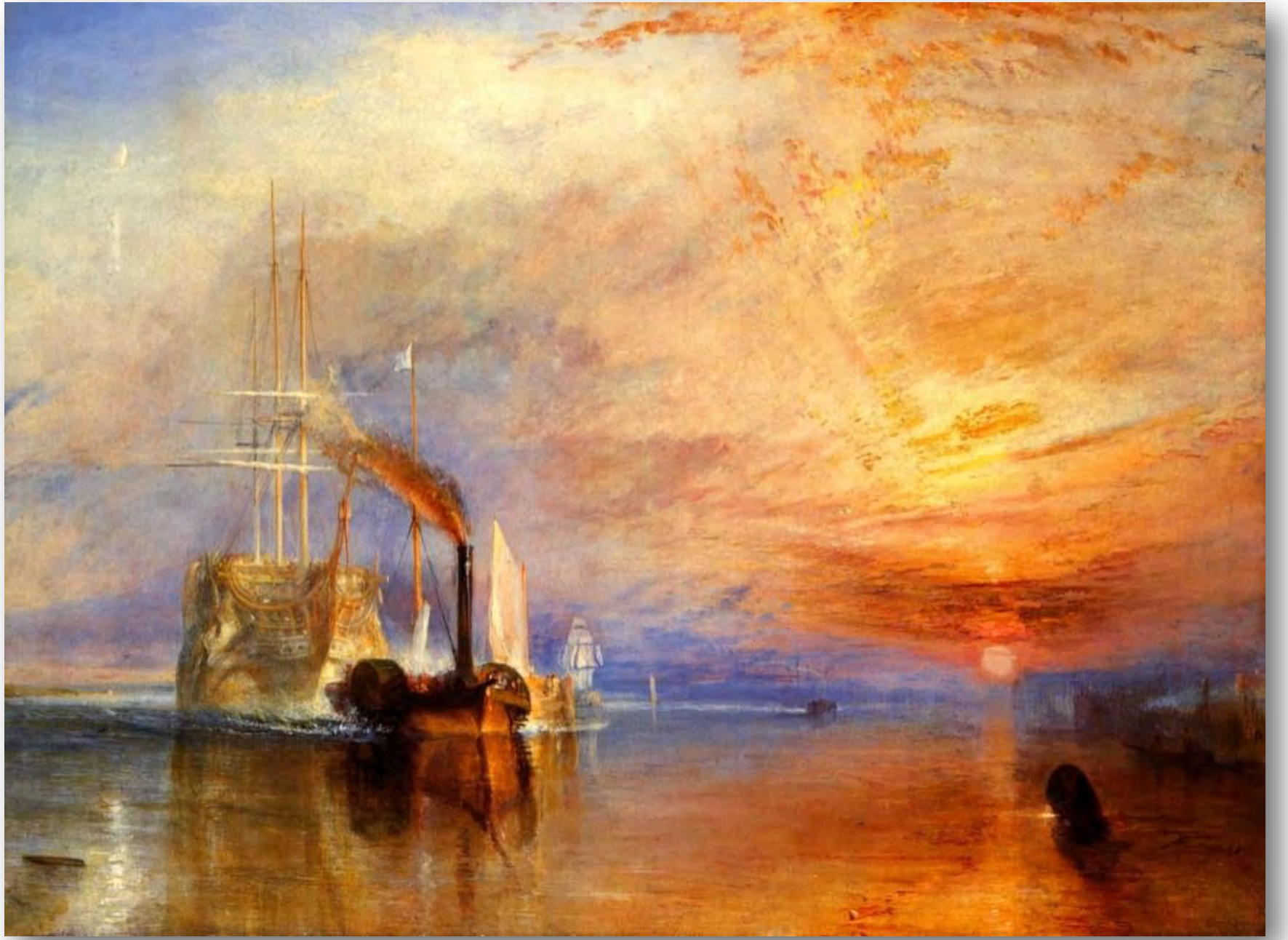
Université de Montréal

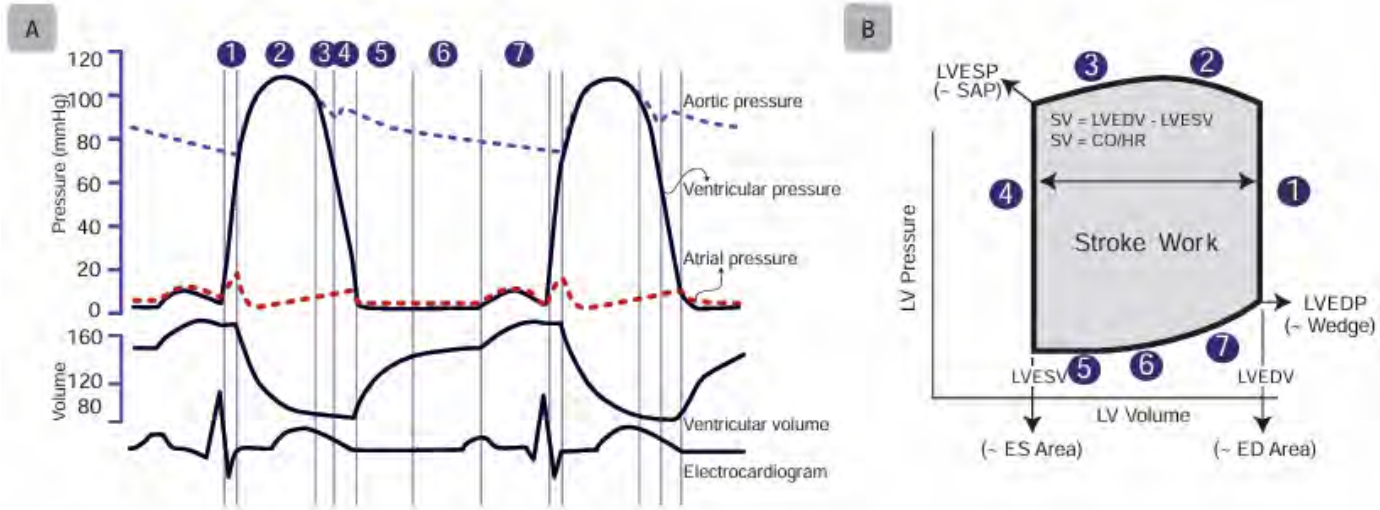
SKYFALL

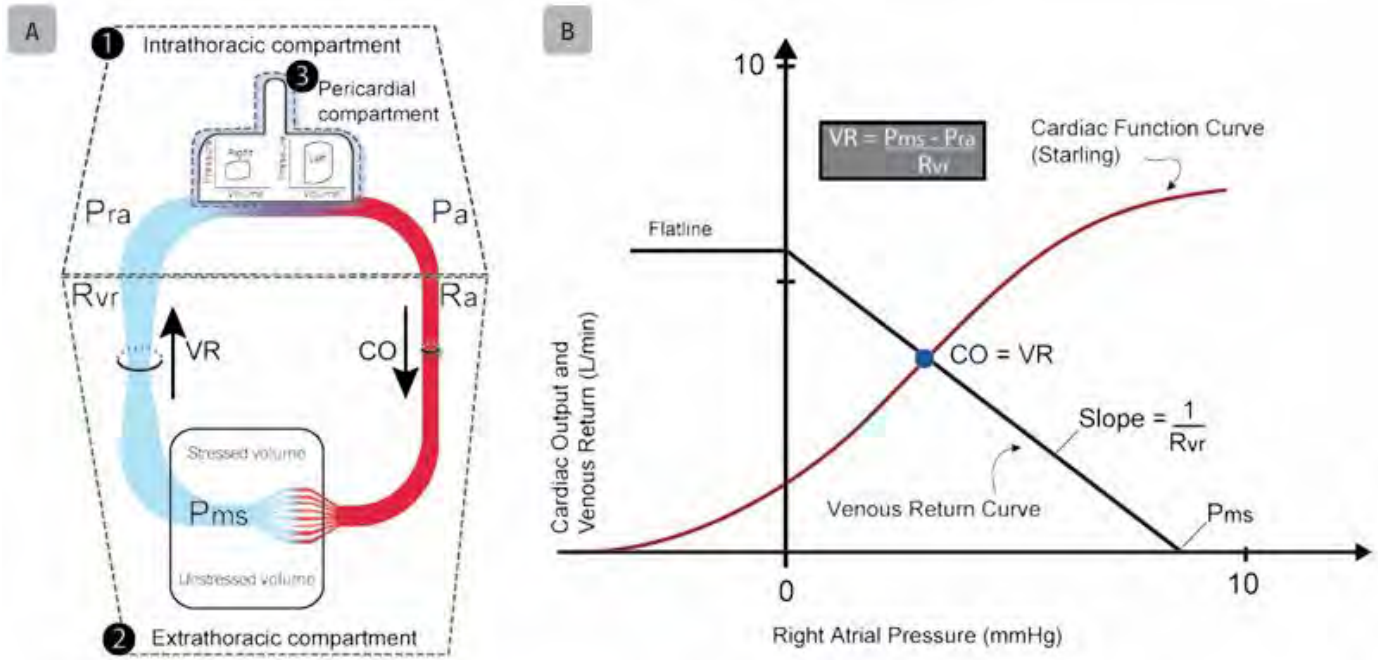
007

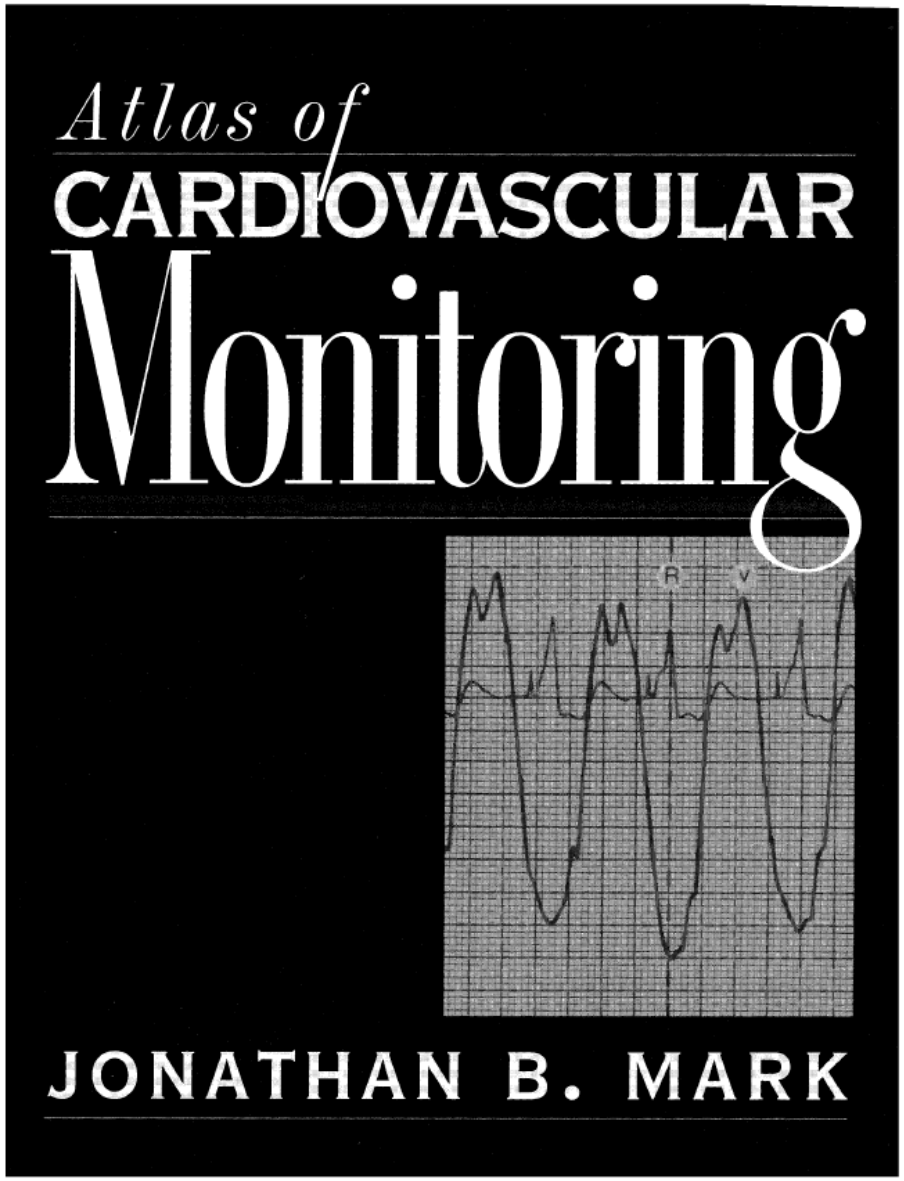
OCTOBER 26

IN IMAX



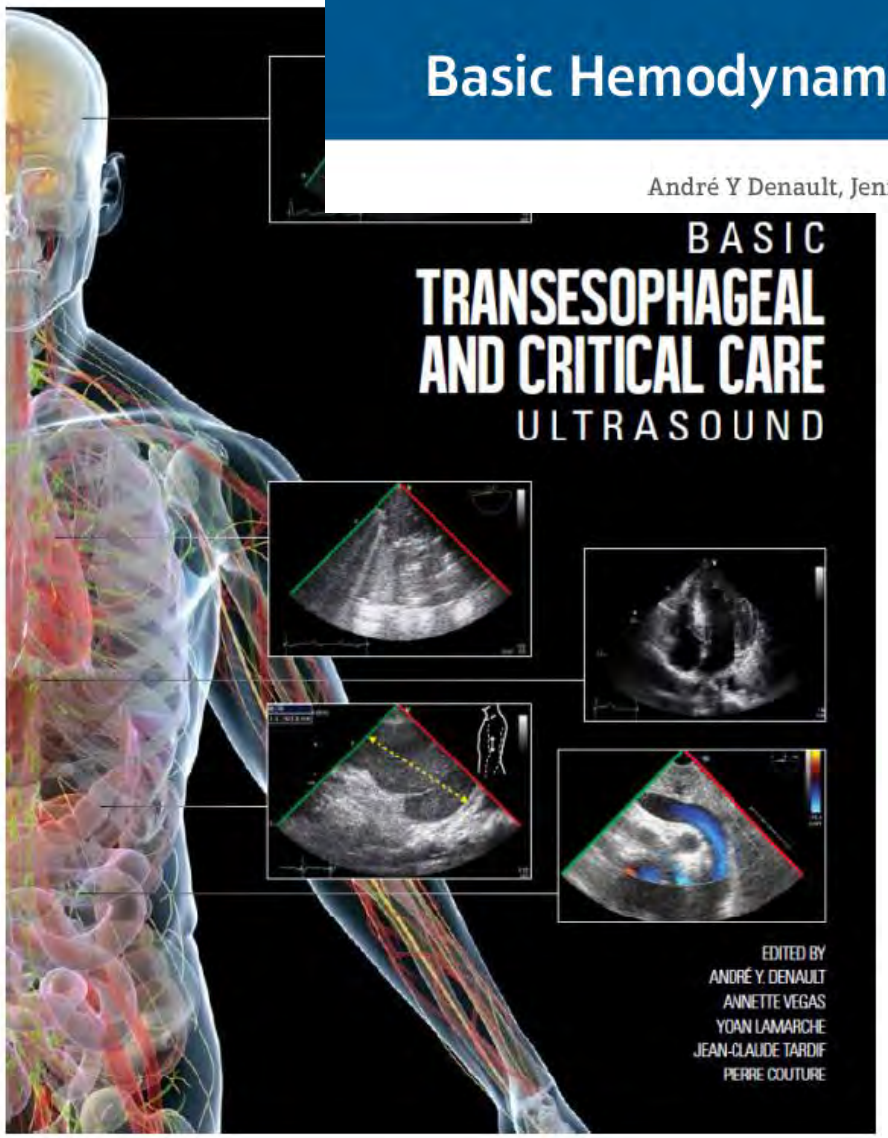

A
1 2 3 4 5 6 7
120
100
80
60
40
20
0
Pressure (mmHg)
160
120
80
Volume
Aortic pressure
Ventricular pressure
Atrial pressure
Ventricular volume
Electrocardiogram
B
LVESP
(~ SAP)
SV = LVEDV - LVESV
SV = CO/HR
Stroke Work
LV Pressure
LVEDP
(~ Wedge)
LVESV
LVEDV
LV Volume
(~ ES Area)
(~ ED Area)


A
1 Intrathoracic compartment
3 Pericardial compartment
Pra
Pa
Rvr
Ra
VR
CO
Stressed volume
Pms
Unstressed volume
2 Extrathoracic compartment
B
10
VR = Pms - Pra / Rvr
Cardiac Function Curve (Starling)
Flatline
CO = VR
Slope = 1/Rvr
Venous Return Curve
Pms
Cardiac Output and Venous Return (L/min)
0
10
Right Atrial Pressure (mmHg)



Chapter 9
Basic Hemodynamic Assessment

André Y Denault, Jennifer Cogan and Annette Vegas



Cours en ligne

- Monitoring du VD Partie 1 (23 min)
  - https://vimeo.com/1092510186
- Assessment of venous congestion with ultrasound (27min)
  - https://vimeo.com/1060166019
- Monitoring hémodynamique
  - https://vimeo.com/890628404

andre.denault@umontreal.ca

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NATIONAL CURRICULUM FOR CANADIAN ANESTHESIOLOGY RESIDENCY

Third Edition
February 2020

Edited by Dr. Michael Cummings MD, FRCPC, Dr. Mark Levine MD, FRCPC, Dr. Hélène Pellerin MD, FRCPC, Dr. Mateen Raazi MD, FRCPC and Jennifer Stewart, MHS

Contributors: ASSOCIATION OF CANADIAN UNIVERSITY DEPARTMENTS OF ANESTHESIA

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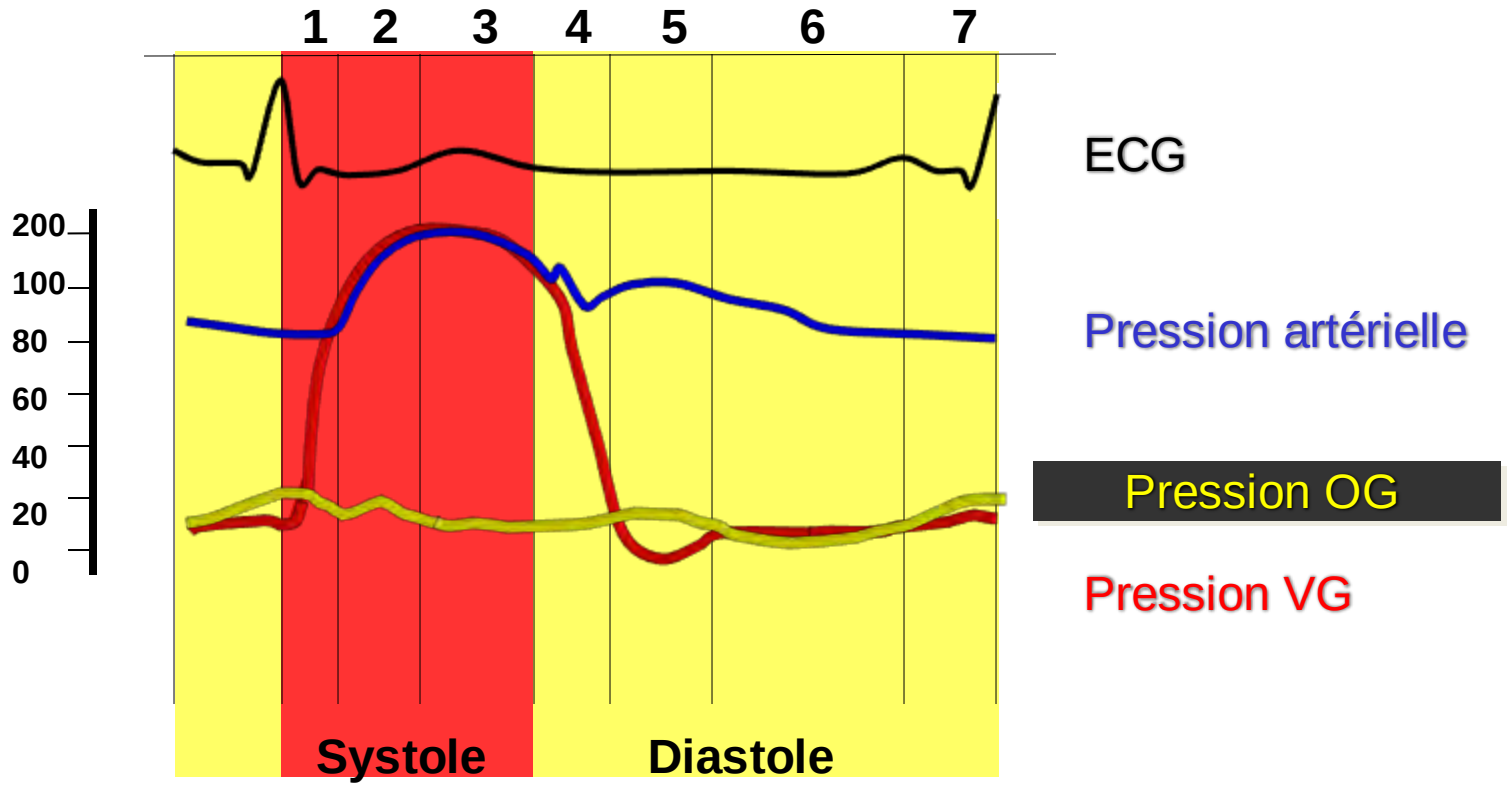
4.2.1.2 Cardiac physiology

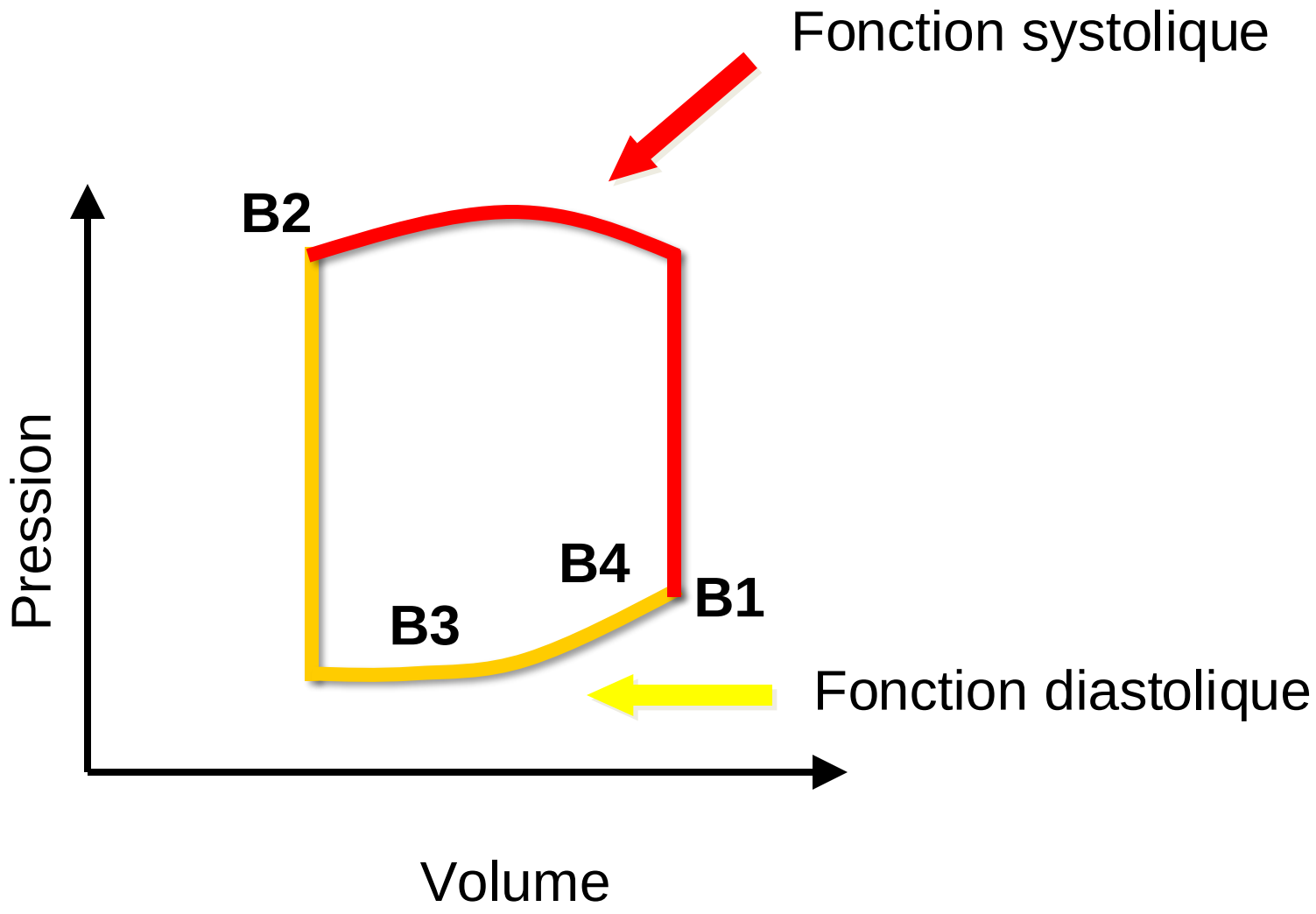
4.2.1.2.1 Describe the phases of the cardiac cycle and relate these to the electrocardiogram

4.2.1.2.2 Discuss the determinants of cardiac output (heart rate and stroke volume), including those variables which influence stroke volume (preload, afterload, contractility)

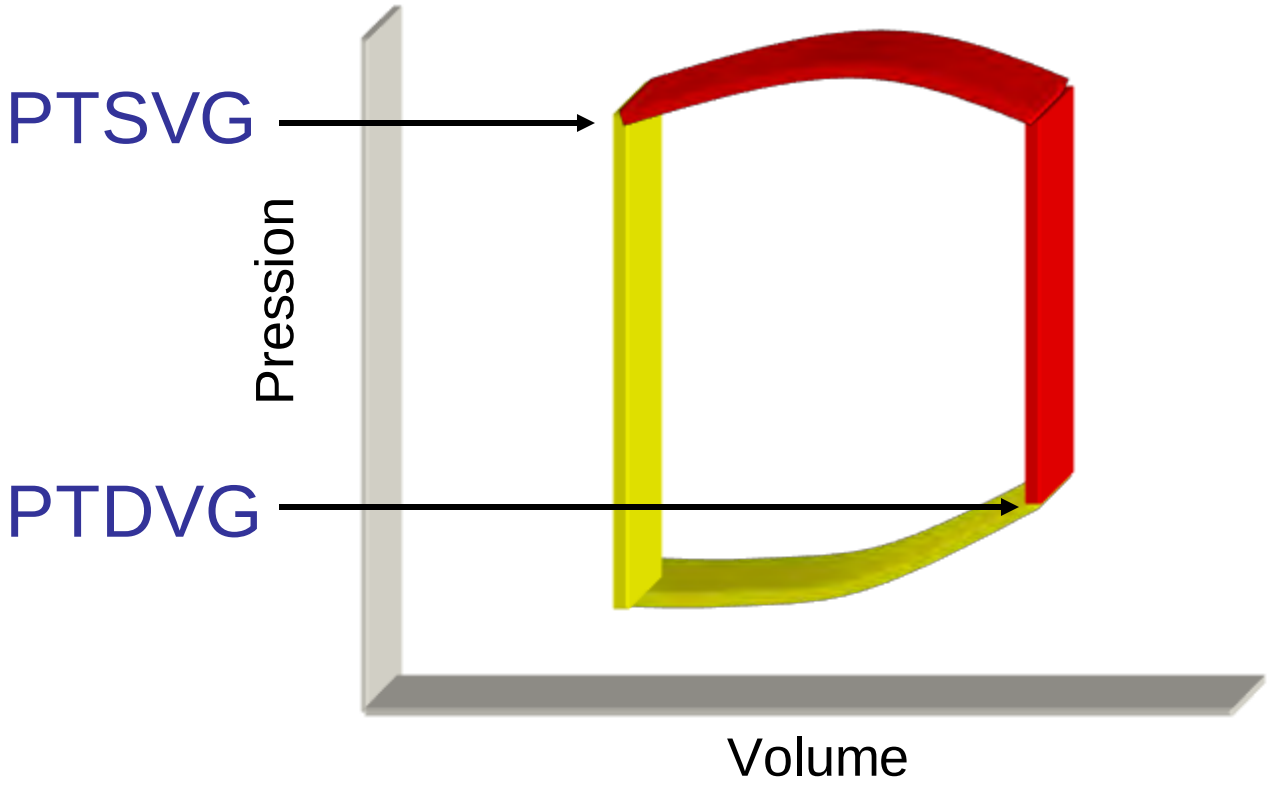
4.2.1.2.3 Describe commonly used indices of systolic function, such as dP/dt, Ejection Fraction (EF), and End Systolic Pressure Volume Relationship (ESPVR); pressure volume loops



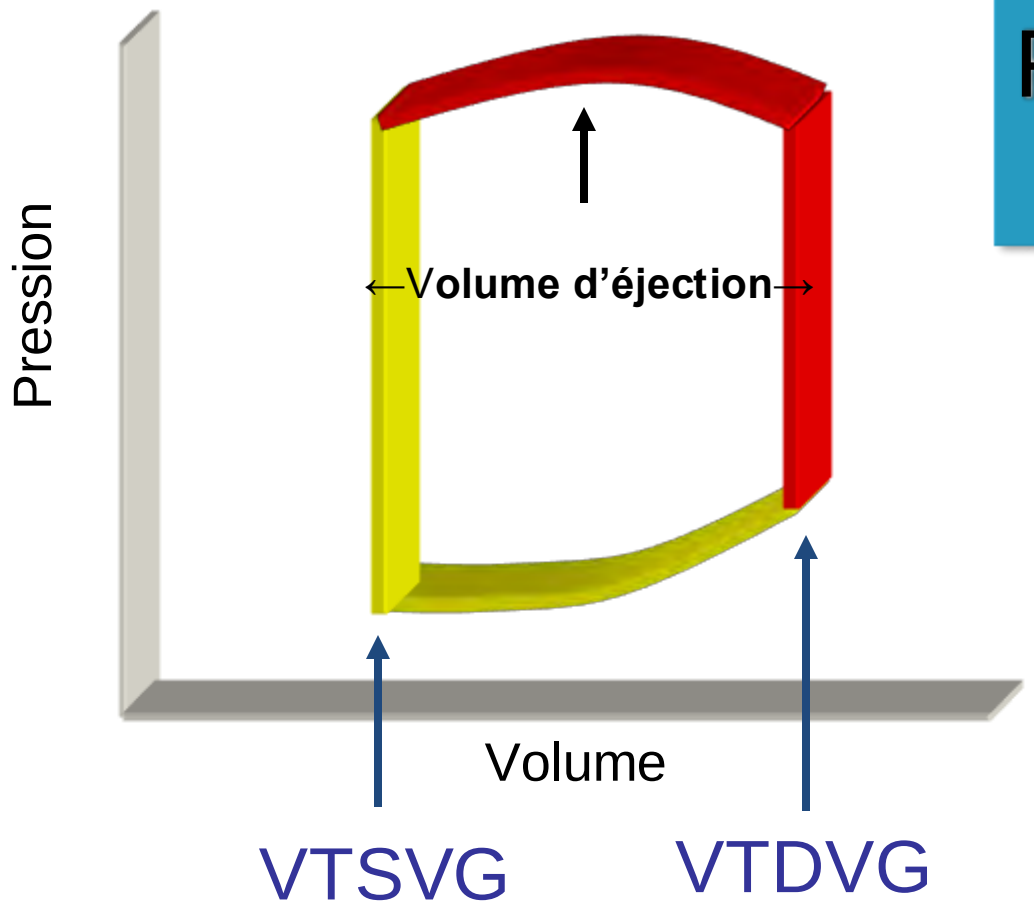
Adapted from Bettex D. Échocardiographie transoesophagienne en anesthésie-réanimation 1997


Fonction systolique
B2
B4
B1
B3
Fonction diastolique
Pression
Volume

Courbe pression-volume



Courbe pression-volume



$$FEVG = \frac{VE}{VTDVG}$$

$$FEVG = \frac{VE}{VTDVG}$$

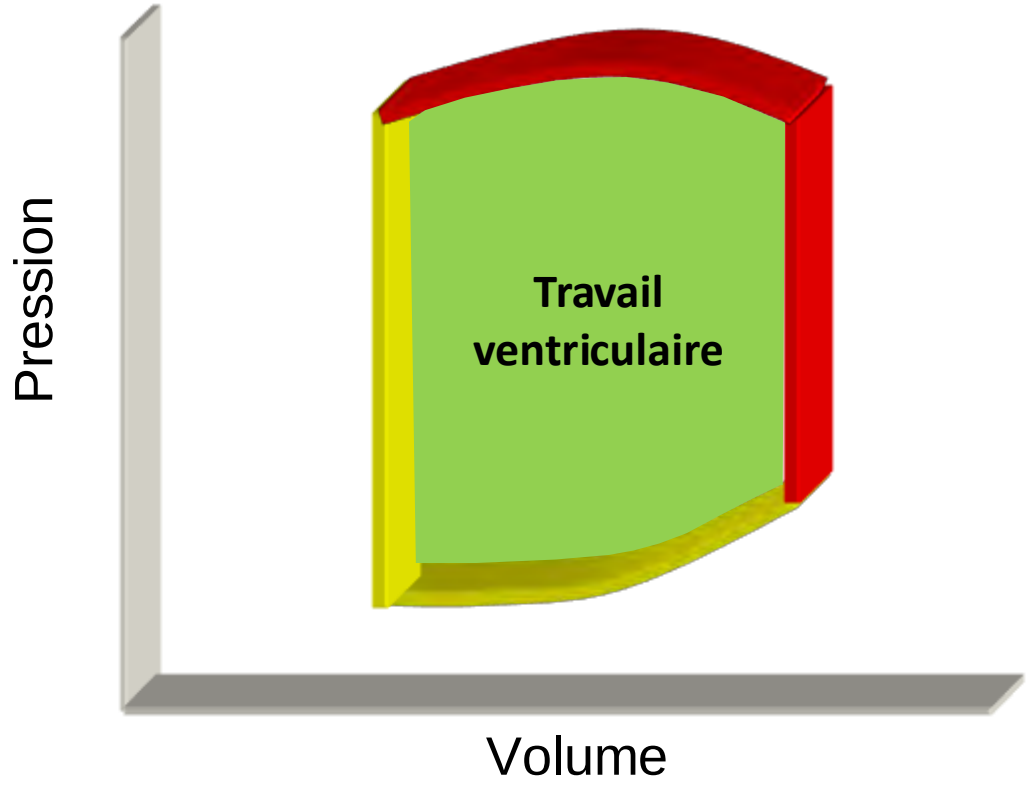
$$VE = FEVG \times VTDVG$$

Performance cardiaque → Fonction systolique

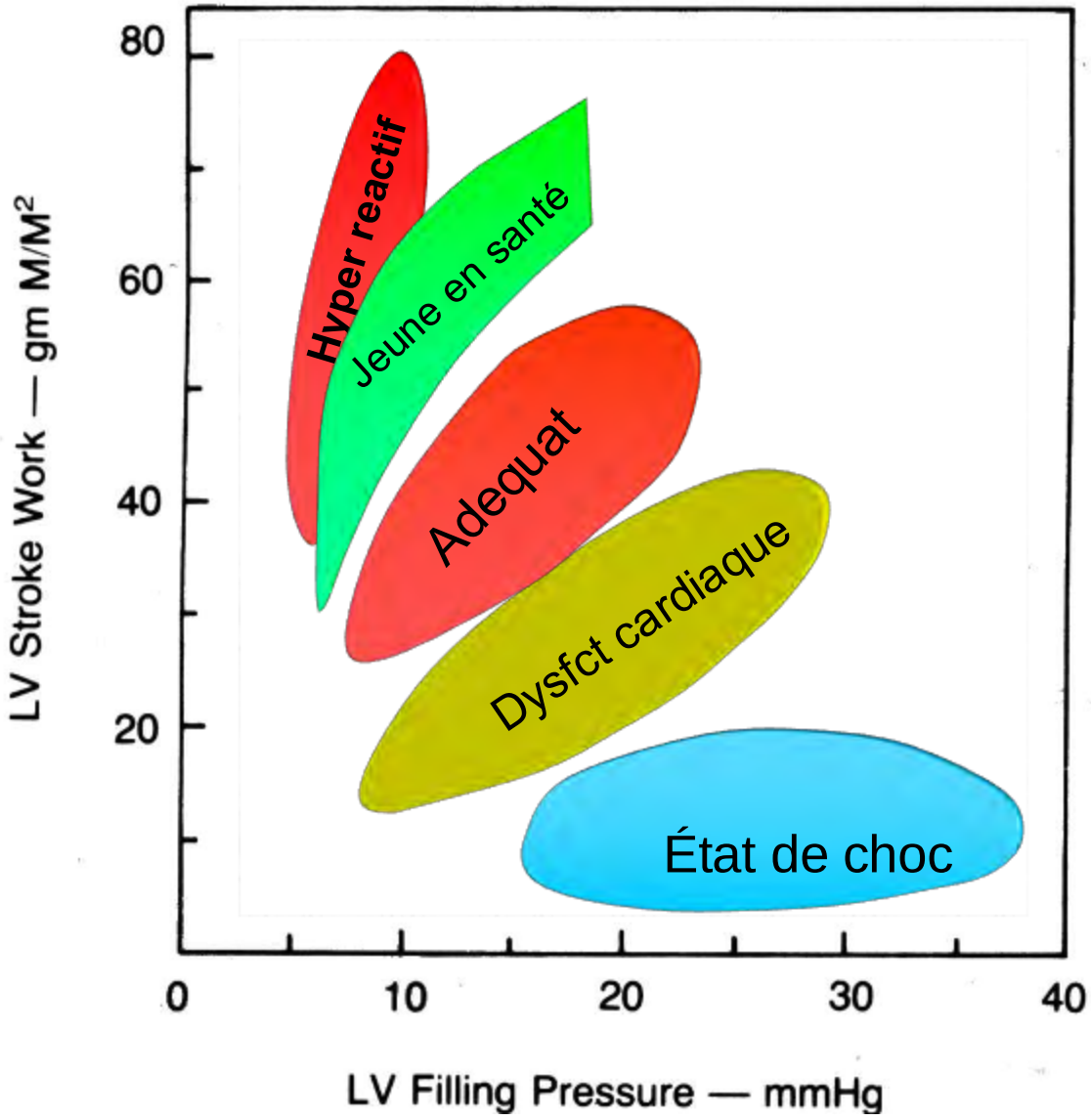
Remplissage → Fonction diastolique

Courbe pression-volume

Travail VG = IC X (PAM-Wedge) X 0.0136



Travail ventriculaire



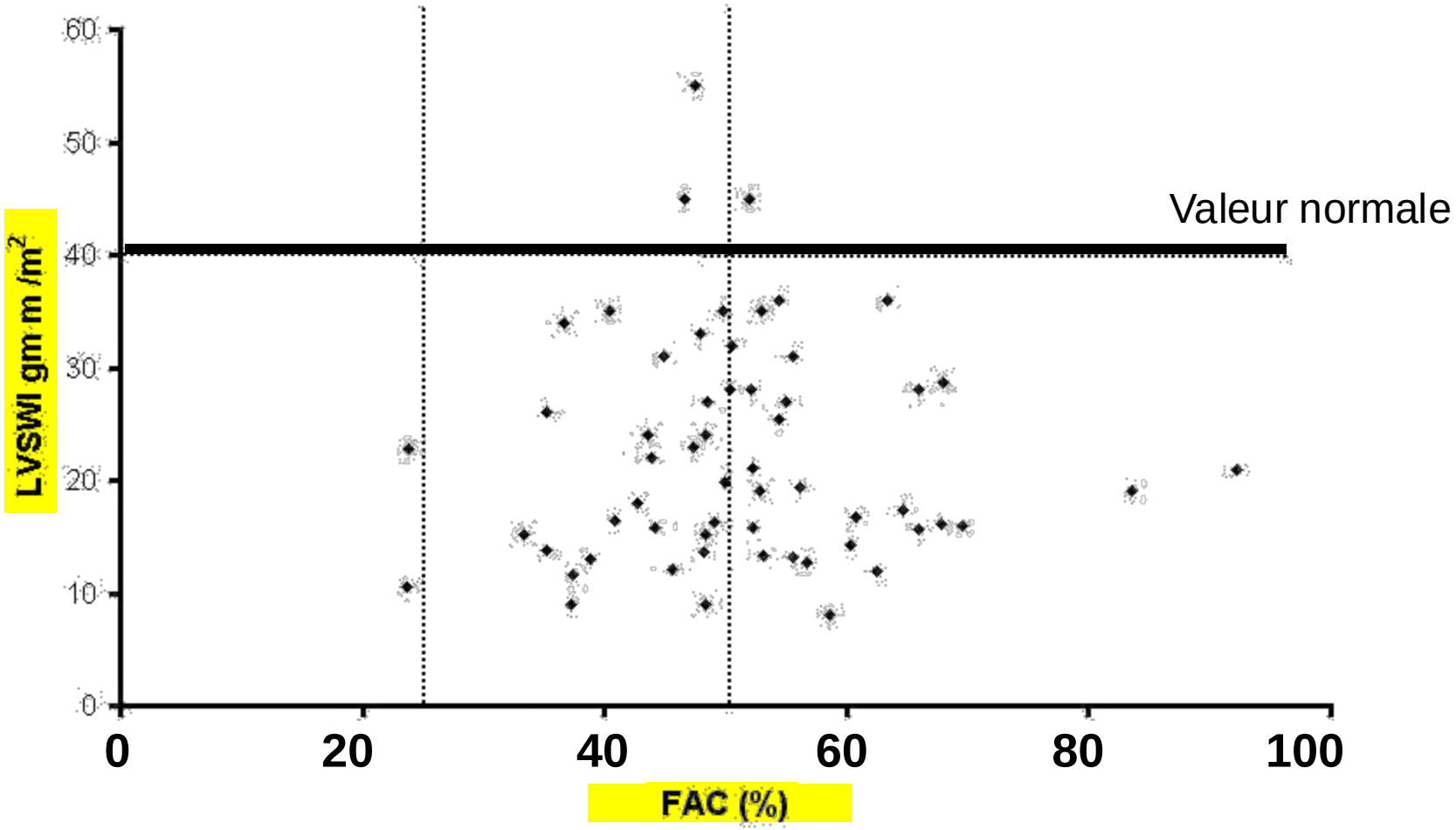
Adaptée de Shoemaker Textbook of critical care Saunders 1989

Poor correlation between hemodynamic and echocardiographic indexes of left ventricular performance in the operating room and intensive care unit

Marie-Josée Bouchard, MD; André Denault, MD; Pierre Couture, MD; Marie-Claude Guertin, PhD; Denis Babin, MSc; Paul Ouellet, RRT, FCCM; Michel Carrier, MD; Jean-Claude Tardif, MD

Critical Care Medicine 2004

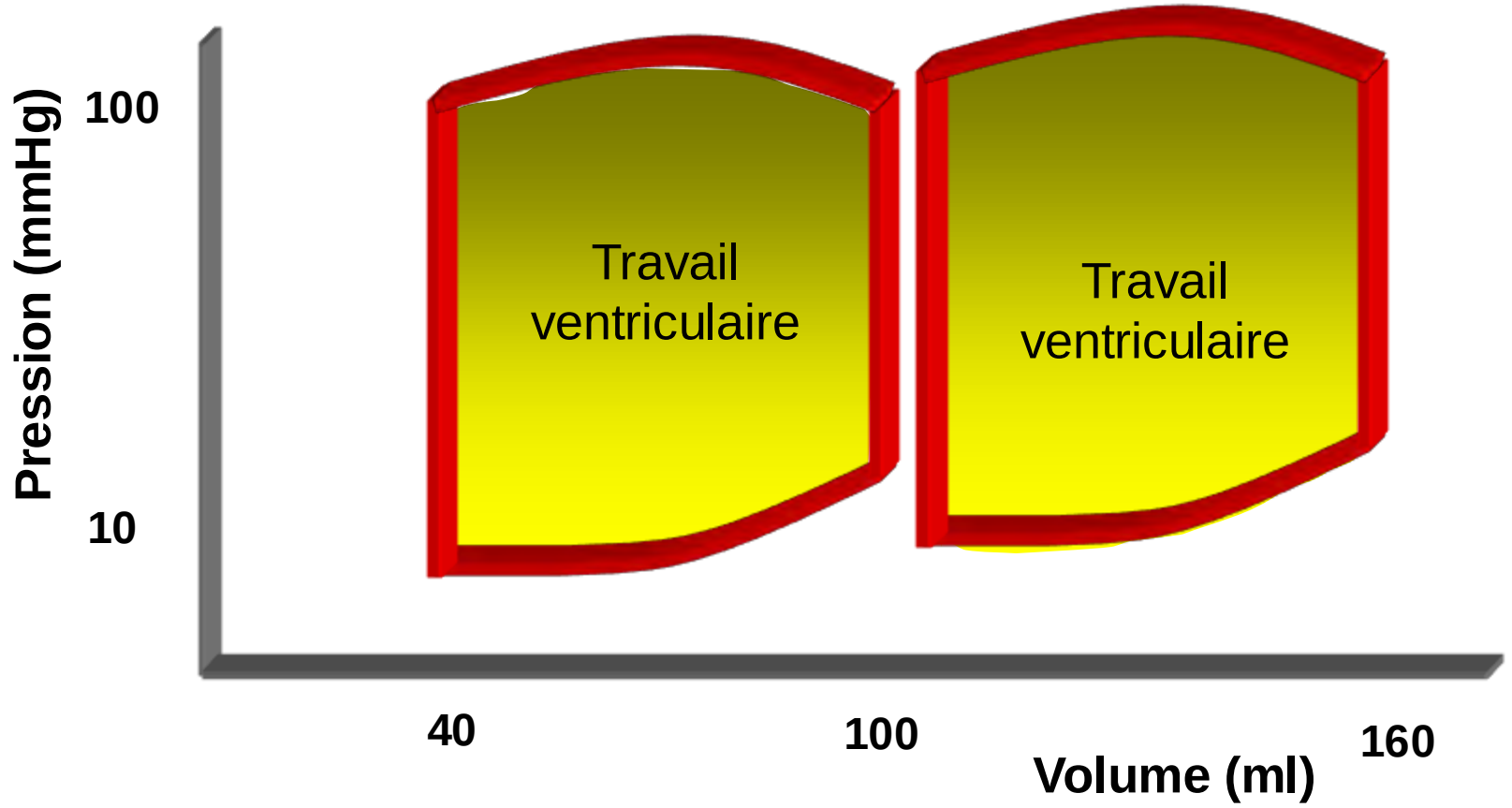
Évaluation hémodynamique et échocardiographique de la performance VG



Bouchard et al CCM 2004

Limitation de la mesure du travail VG

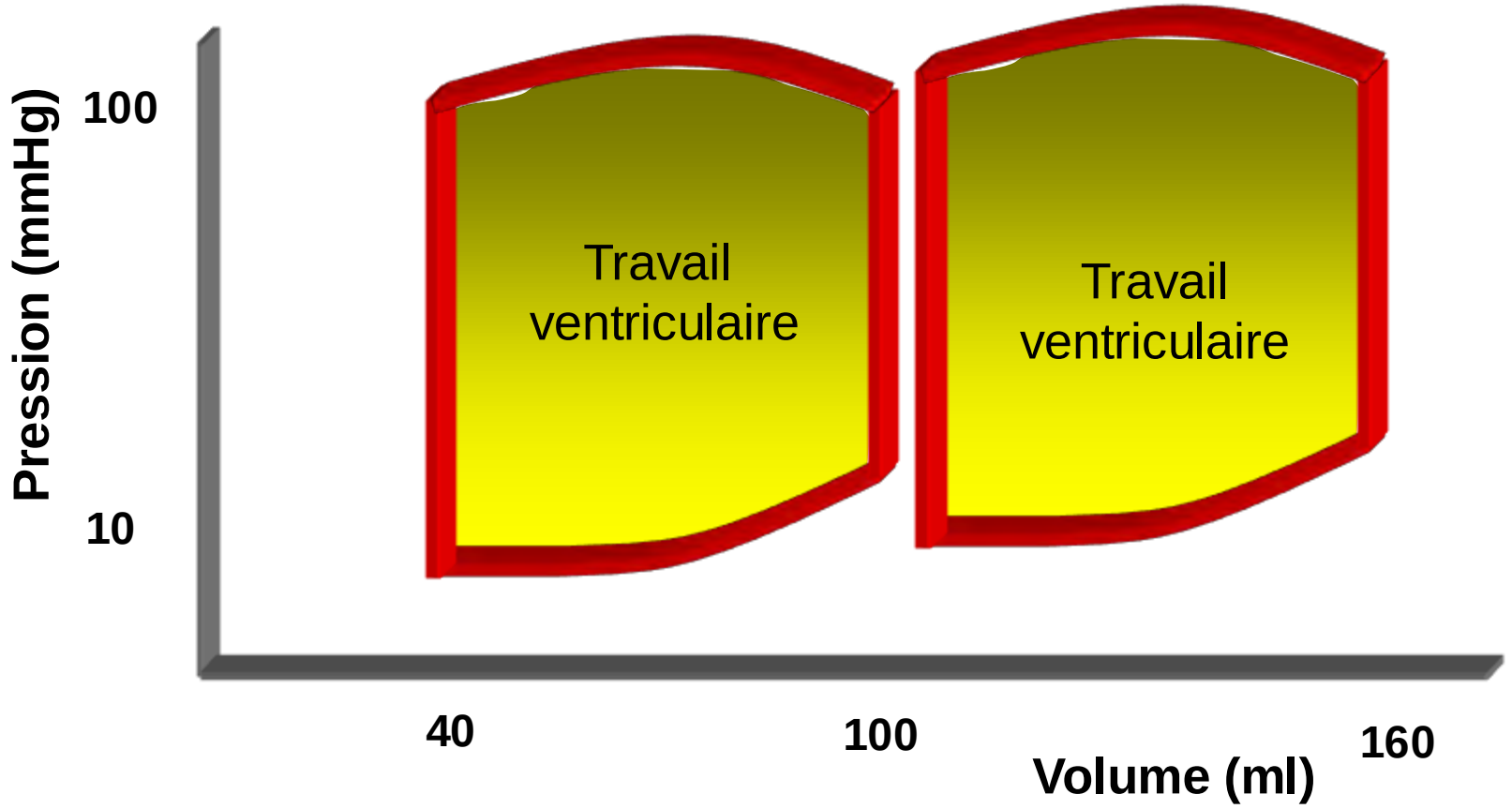
Volume d'éjection	60 ml	60 ml
Travail VG (X 0.0136)	60 X (100-10)	60 X (100-10)

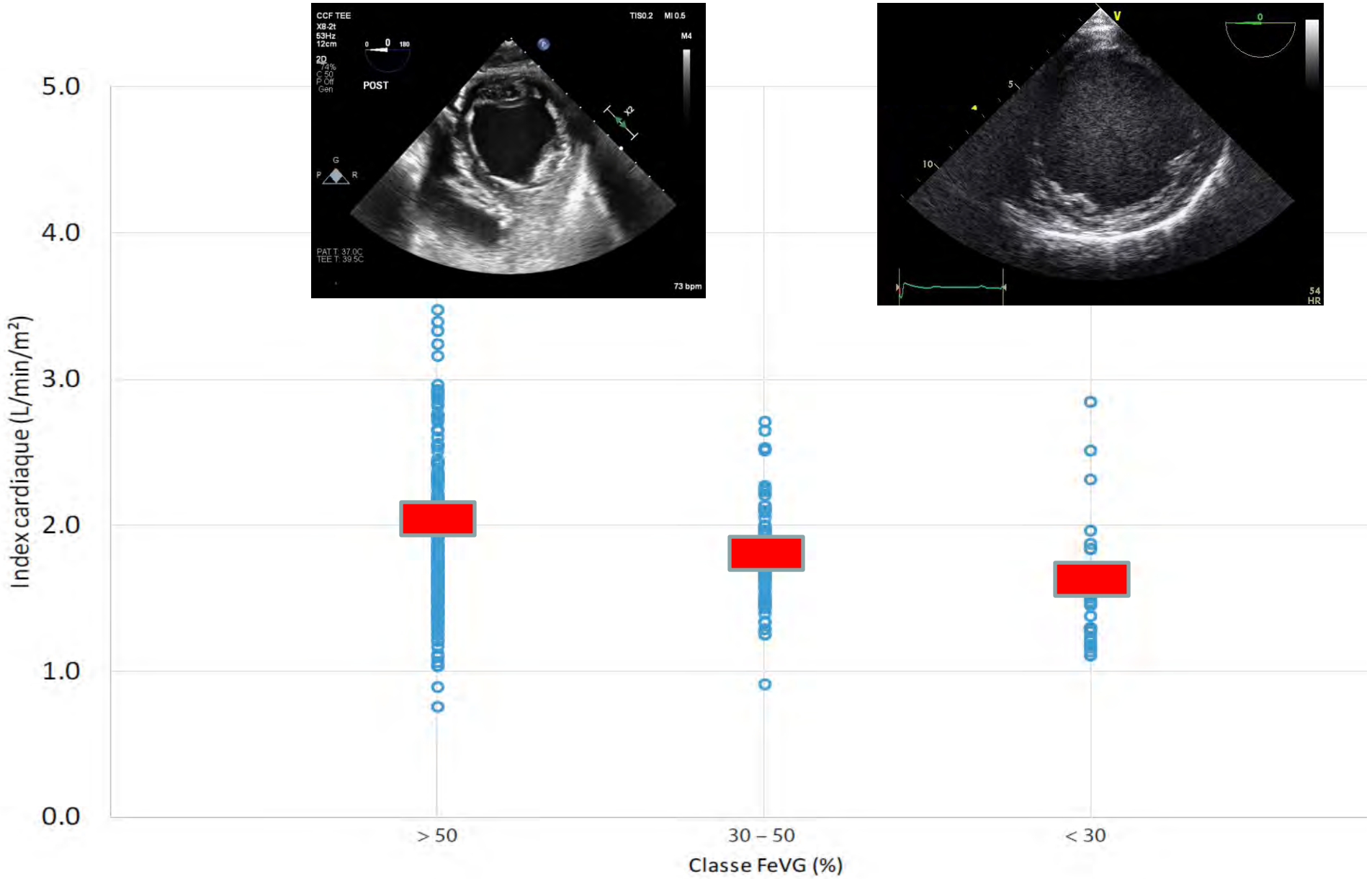


Limitation de la mesure du travail VG

Fraction d'éjection VG 60 ml/100ml = 60%

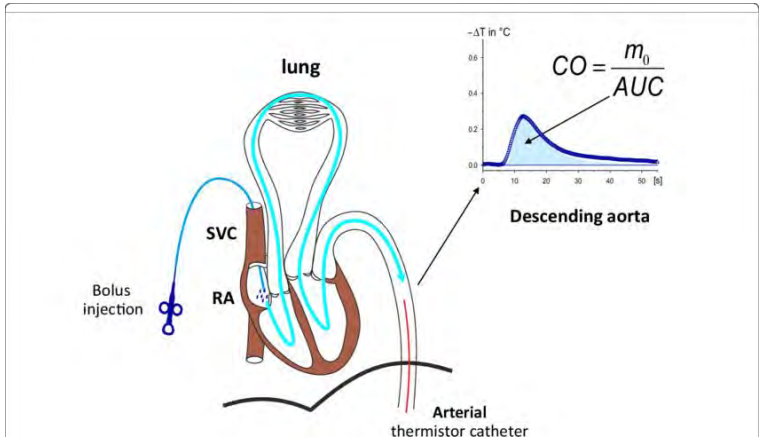
60 ml/160ml = 40%

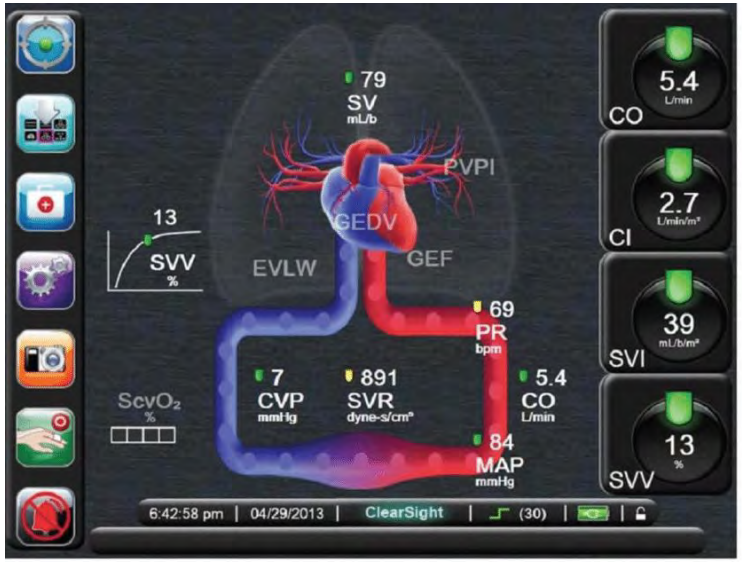




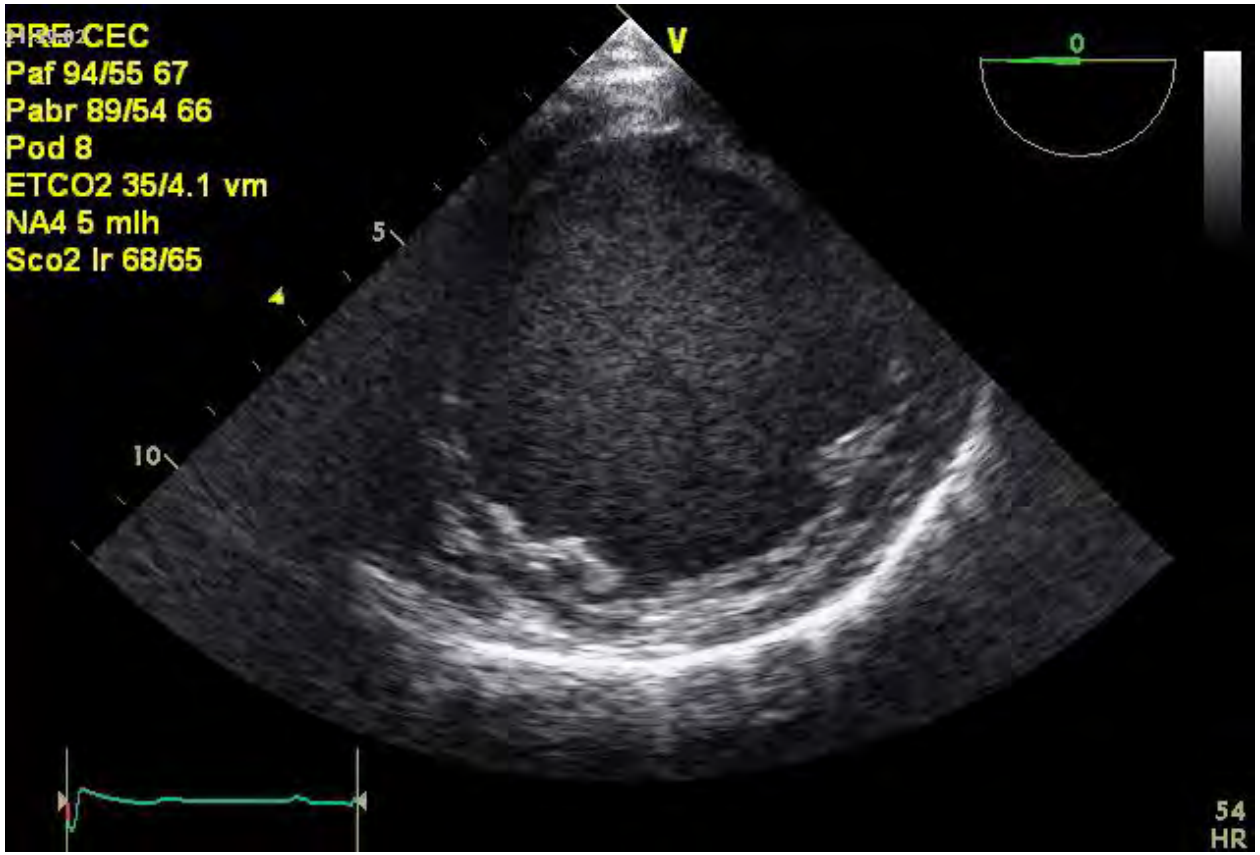
N = 310 patients

Point clé


lung
$CO = \frac{m_0}{AUC}$
Descending aorta
SVC
RA
Bolus injection
Arterial thermistor catheter


79
SV
mL/b
PVPI
GEDV
13
SVV
%
EVLW
GEF
69
PR
bpm
7
CVP
mmHg
891
SVR
dyne-s/cm⁵
5.4
CO
L/min
84
MAP
mmHg
ScvO₂
%
5.4
CO
2.7
CI
39
SVI
13
SVV
6:42:58 pm | 04/29/2013 | ClearSight | (30)

≠


PRE-CEC
Paf 94/55 67
Pabr 89/54 66
Pod 8
ETCO2 35/4.1 vm
NA4 5 mlh
Sco2 lr 68/65
V
0
5
10
54
HR

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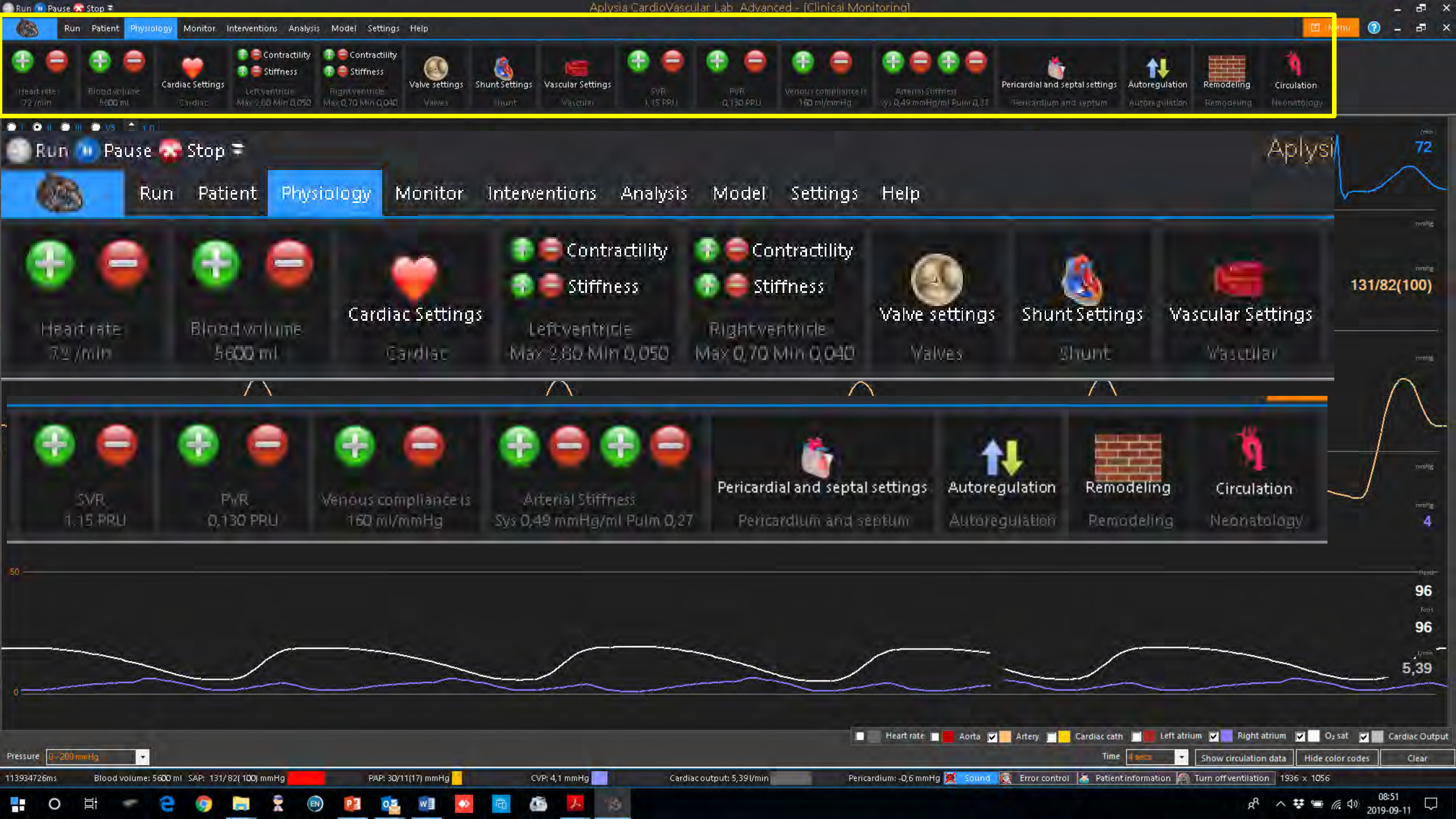
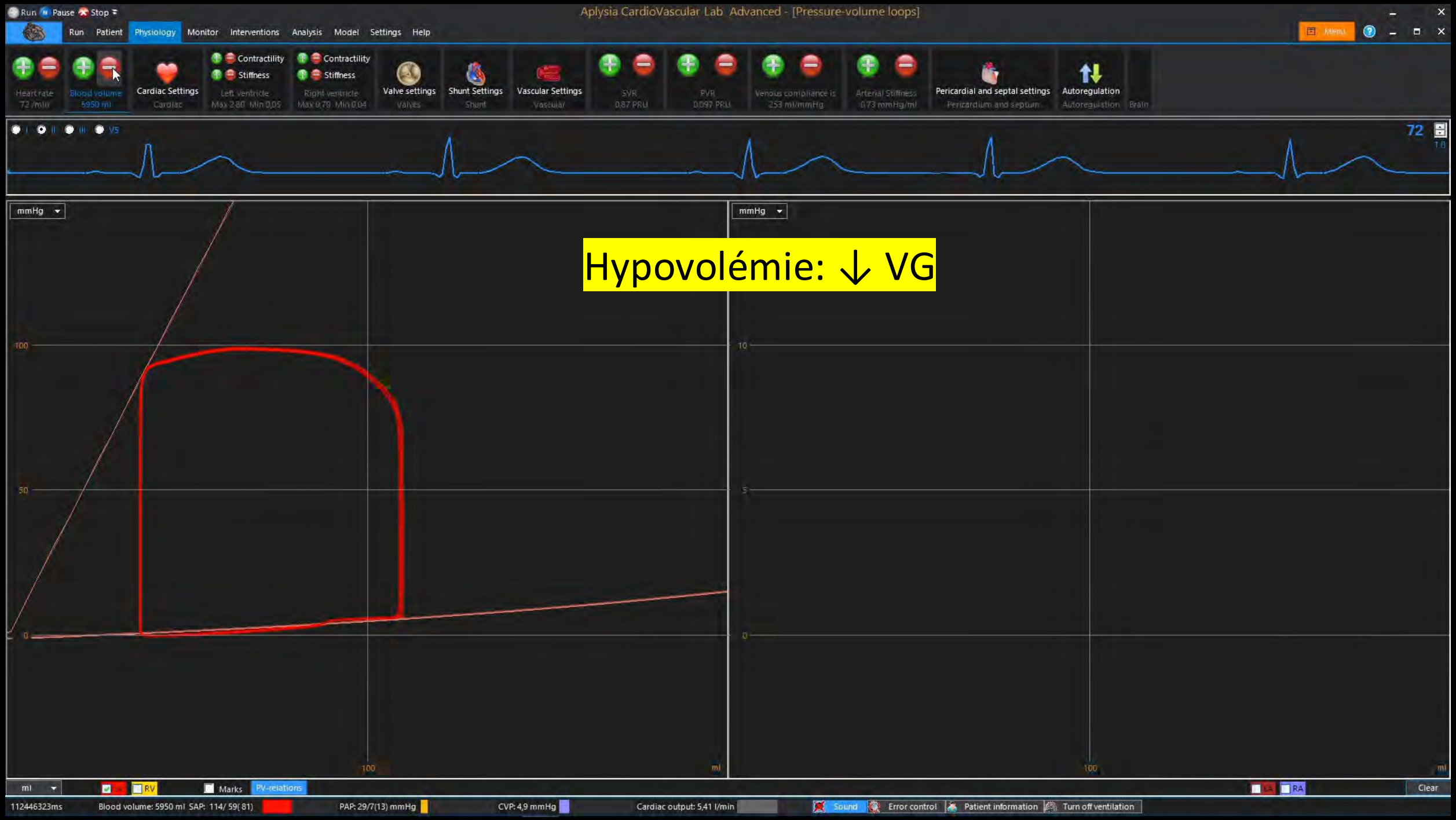
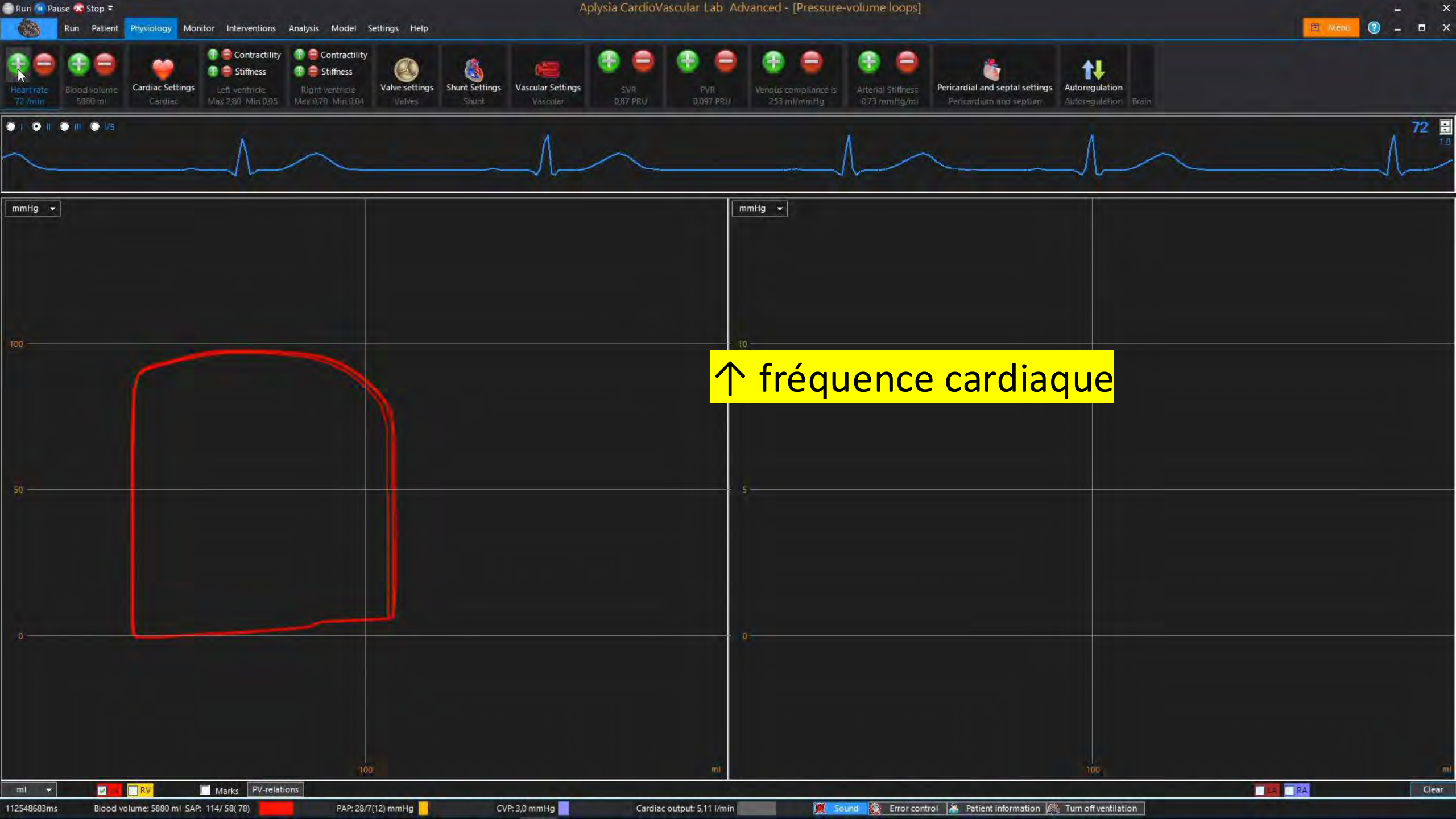
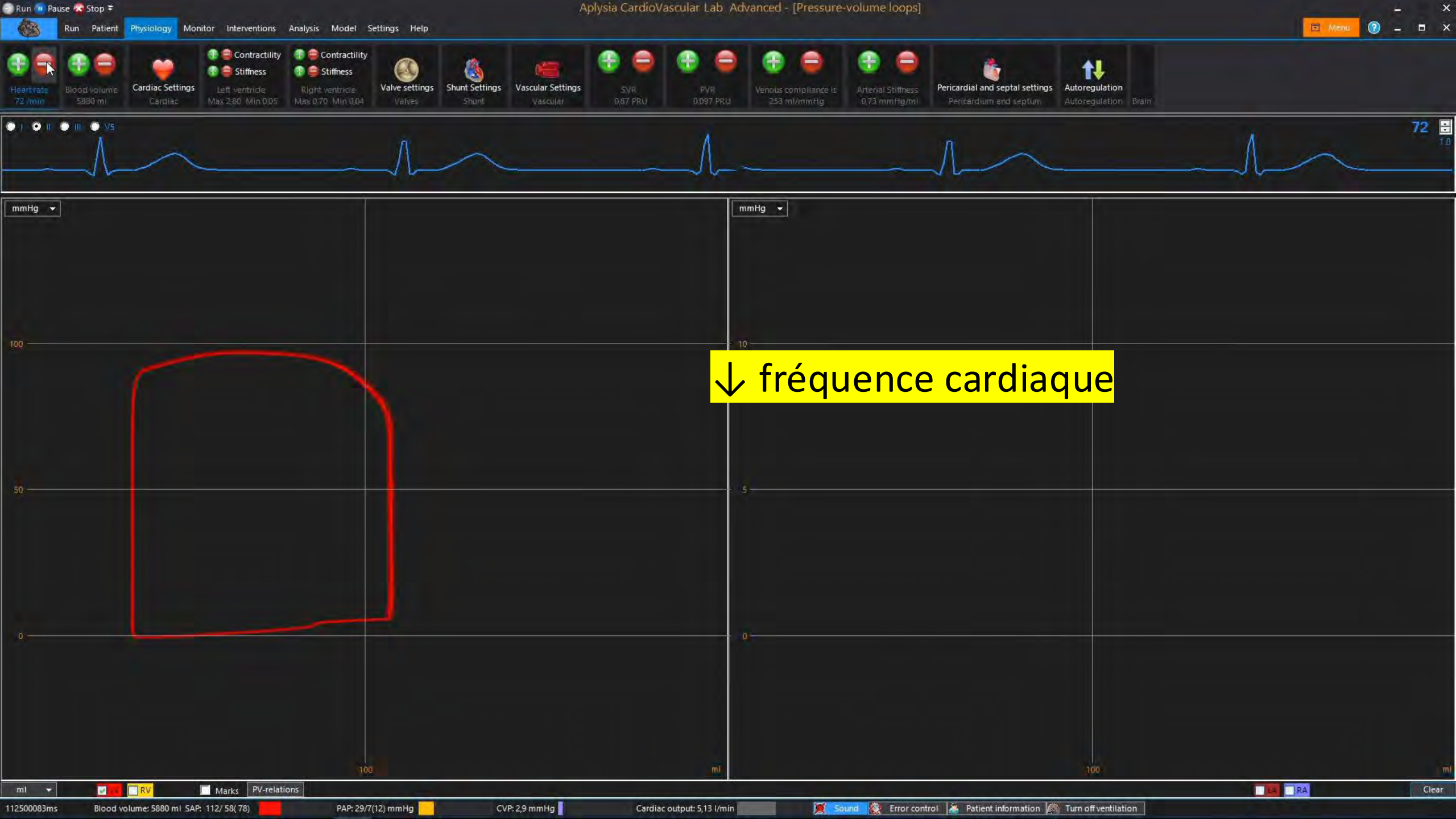
Aplysia CardioVascular Lab 2014.

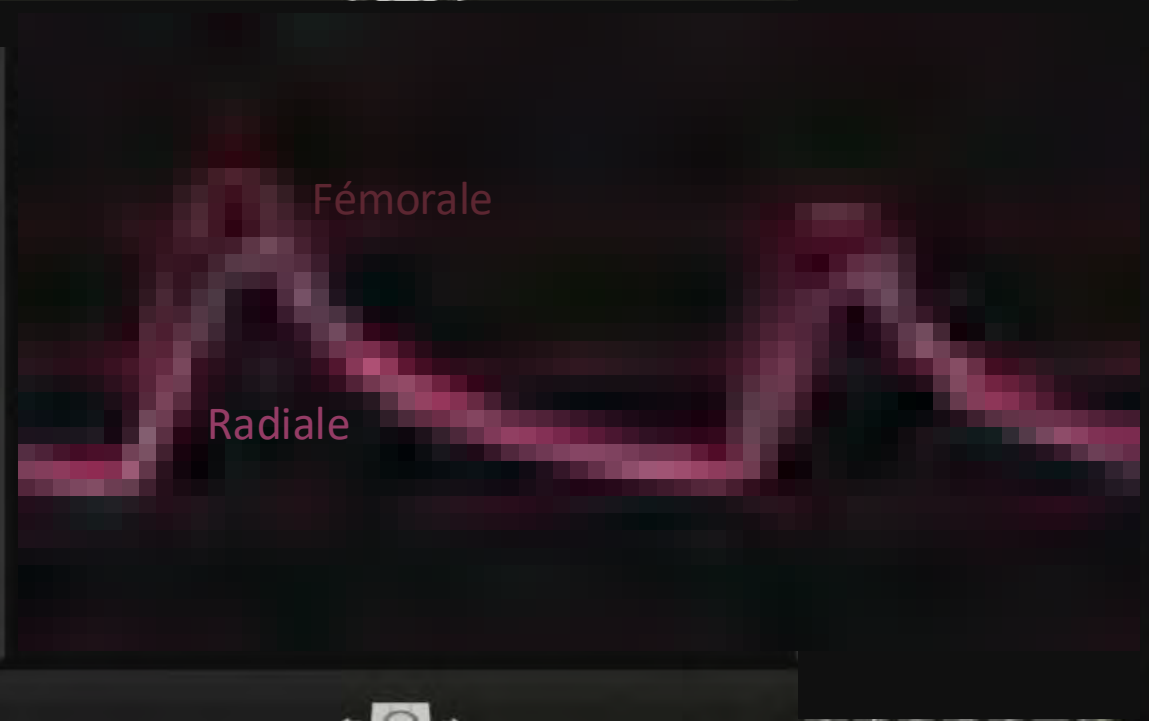

Run Pause Stop
Aplysia CardioVascular Lab Advanced - [Clinical Monitoring]
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Menu
Heart rate 72 /min
Blood volume 5600 ml
Cardiac Settings
Cardiac
Contractility
Stiffness
Left ventricle Max 2,80 Min 0,050
Contractility
Stiffness
Right ventricle Max 0,70 Min 0,040
Valve settings
Valves
Shunt Settings
Shunt
Vascular Settings
Vascular
SVR 1,15 PRU
PVR 0,130 PRU
Venous compliance is 160 ml/mmHg
Arterial Stiffness Sys 0,49 mmHg/ml Pulm 0,27
Pericardial and septal settings
Pericardium and septum
Autoregulation
Autoregulation
Remodeling
Remodeling
Circulation
Neonatology
Aplysi
72
131/82(100)
4
96
96
5,39
50
0
Heart rate
Aorta
Artery
Cardiac cath
Left atrium
Right atrium
O2 sat
Cardiac Output
Pressure
0 - 200 mmHg
Time
4 secs
Show circulation data
Hide color codes
Clear
113934726ms
Blood volume: 5600 ml
SAP: 131/82(100) mmHg
PAP: 30/11(17) mmHg
CVP: 4,1 mmHg
Cardiac output: 5,39 l/min
Pericardium: -0,6 mmHg
Sound
Error control
Patient information
Turn off ventilation
1936 x 1056
08:51
2019-09-11


Run Pause Stop
Aplysia CardioVascular Lab Advanced - [Pressure-volume loops]
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Menu
Heart rate 72 /min
Blood volume 5950 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2.80 Min 0.05
Contractility Stiffness Right ventricle Max 0.79 Min 0.04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0.87 PRU
PVR 0.097 PRU
Venous compliance is 253 ml/mmHg
Arterial Stiffness 0.73 mmHg/ml
Pericardial and septal settings Pericardium and septum
Autoregulation Autoregulation
Brain
I II III V5
72
mmHg
100
50
0
100
ml
mmHg
10
5
0
100
ml
Hypovolémie: ↓ VG
ml
RV
Marks
PV-relations
LA
RA
Clear
112446323ms
Blood volume: 5950 ml SAP: 114/ 59(81)
PAP: 29/7(13) mmHg
CVP: 4,9 mmHg
Cardiac output: 5,41 l/min
Sound
Error control
Patient information
Turn off ventilation

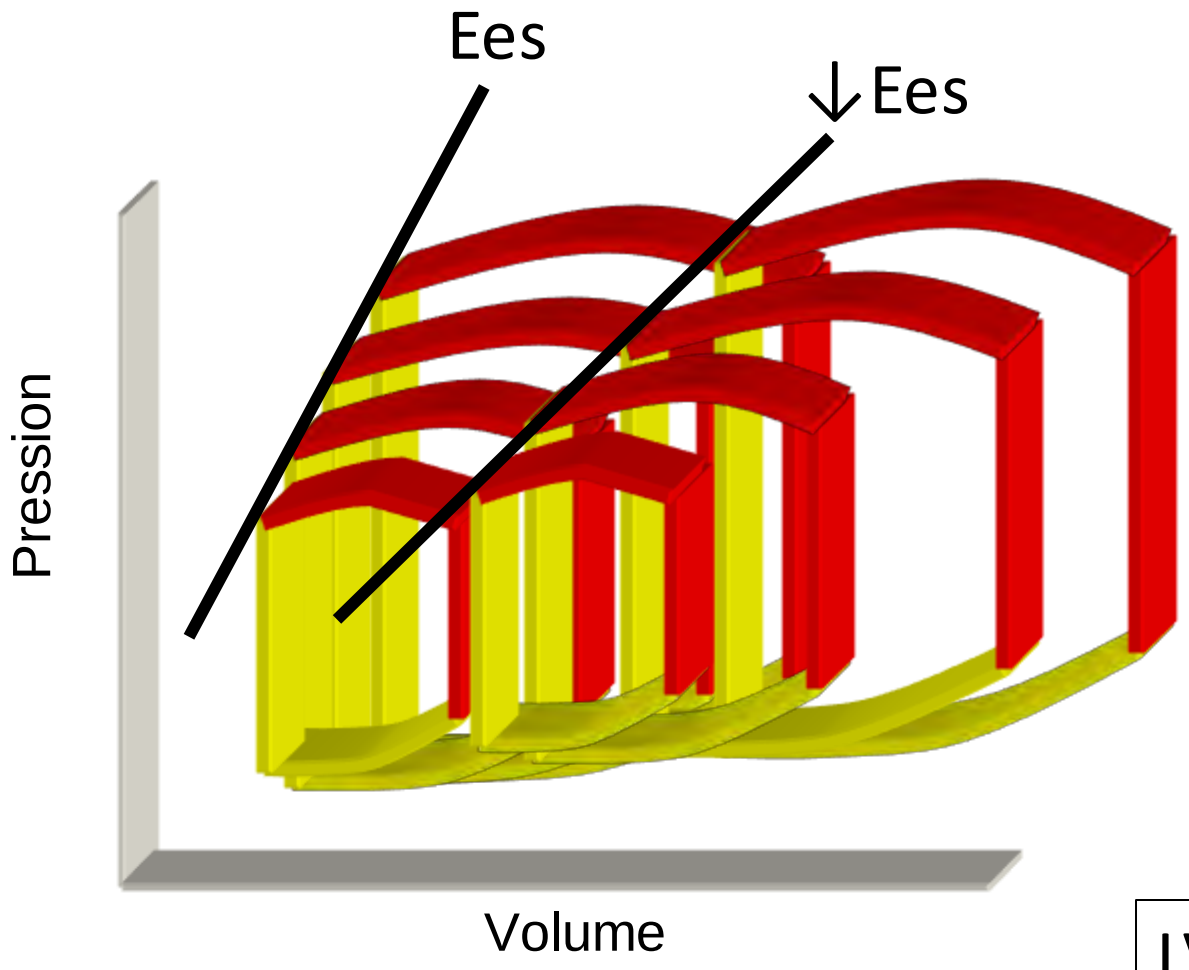

Run Pause Stop
Aplysia CardioVascular Lab Advanced - [Pressure-volume loops]
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Menu
Heart rate 72 /min
Blood volume 5880 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2,80 Min 0,05
Contractility Stiffness Right ventricle Max 0,70 Min 0,04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0,87 PRU
PVR 0,097 PRU
Venous compliance is 253 ml/mmHg
Arterial Stiffness 0,73 mmHg/ml
Pericardial and septal settings Pericardium and septum
Autoregulation Autoregulation
Brain
I II III V5
72
1.0
mmHg
100
50
0
100
ml
mmHg
10
5
0
100
ml
↑ fréquence cardiaque
ml
RV
Marks
PV-relations
LA
RA
Clear
112548683ms
Blood volume: 5880 ml SAP: 114/ 58(78)
PAP: 28/7(12) mmHg
CVP: 3,0 mmHg
Cardiac output: 5,11 l/min
Sound
Error control
Patient information
Turn off ventilation


Run Pause Stop
Aplysia CardioVascular Lab Advanced - [Pressure-volume loops]
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Menu
Heartrate 72 /min
Blood volume 5880 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2.80 Min 0.05
Contractility Stiffness Right ventricle Max 0.70 Min 0.04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0.87 PRU
PVR 0.097 PRU
Venous compliance is 253 ml/mmHg
Arterial Stiffness 0.73 mmHg/ml
Pericardial and septal settings Pericardium and septum
Autoregulation Autoregulation
Brain
I II III V5
72
1.0
mmHg
100
50
0
100
ml
mmHg
10
5
0
100
ml
↓ fréquence cardiaque
ml
RV
Marks
PV-relations
LA
RA
Clear
112500083ms
Blood volume: 5880 ml SAP: 112/ 58(78)
PAP: 29/7(12) mmHg
CVP: 2,9 mmHg
Cardiac output: 5,13 l/min
Sound
Error control
Patient information
Turn off ventilation

♂ 59 post PAC-RVA



Courbe pression-volume

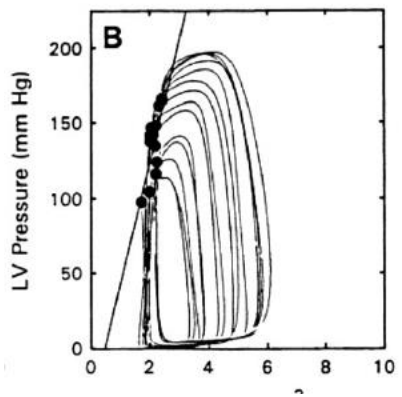


LV Ees = PTSVG/VTSVG

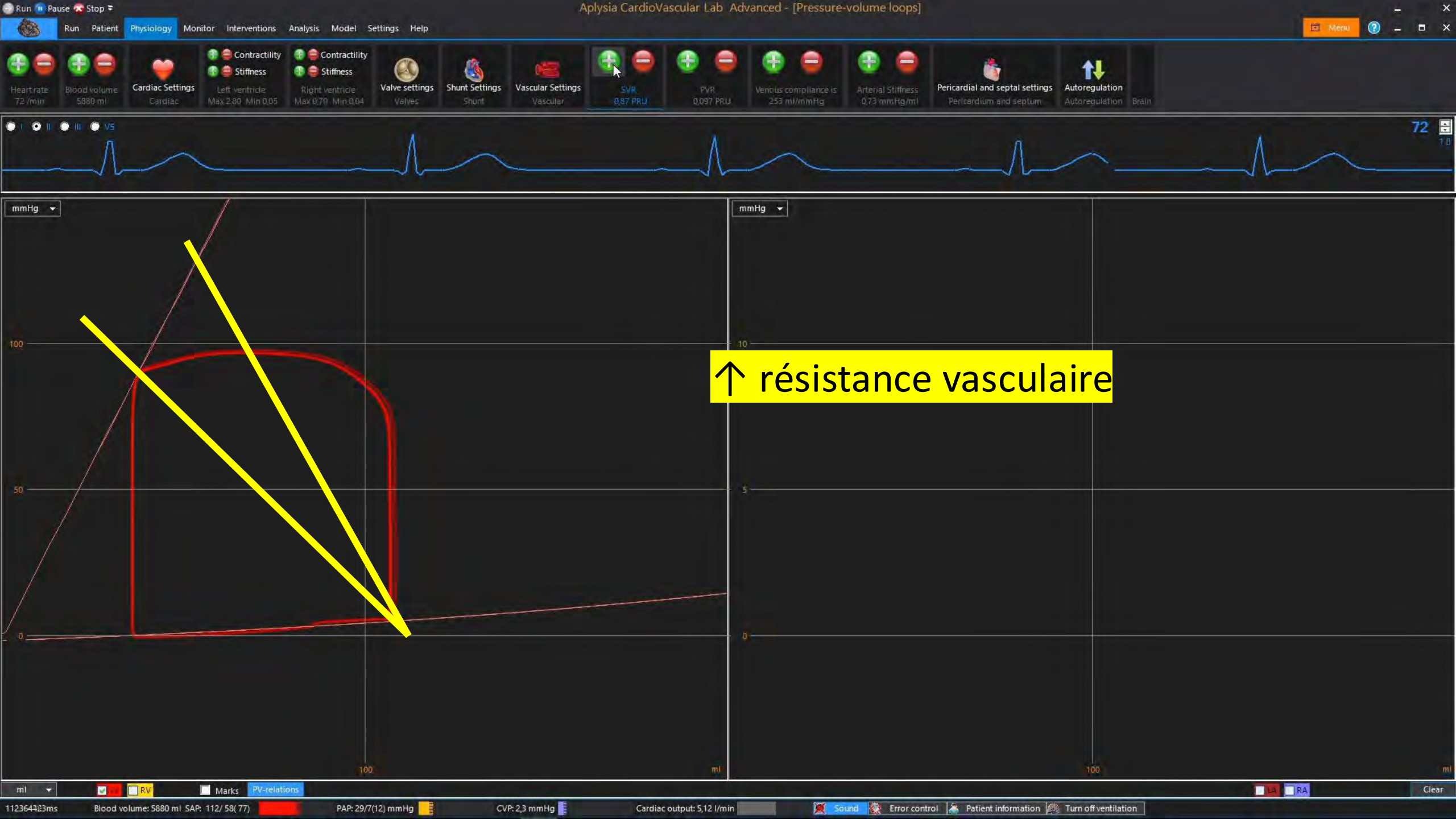

Run
Pause
Stop
Aplysia CardioVascular Lab Advanced - [Pressure-volume loops]
Run
Patient
Physiology
Monitor
Interventions
Analysis
Model
Settings
Help
Menu
Heart rate
72 /min
Blood volume
5880 ml
Cardiac Settings
Cardiac
Contractility
Stiffness
Left ventricle
Max 2,80 Min 0,05
Contractility
Stiffness
Right ventricle
Max 0,70 Min 0,04
Valve settings
Valves
Shunt Settings
Shunt
Vascular Settings
Vascular
SVR
0,87 PRU
PVR
0,097 PRU
Venous compliance is
253 ml/mmHg
Arterial Stiffness
0,73 mmHg/ml
Pericardial and septal settings
Pericardium and septum
Autoregulation
Autoregulation
Brain
I
II
III
V5
72
mmHg
100
50
0
100
ml
mmHg
5
0
100
ml
↓contractilité
ml
RV
Marks
PV-relations
LA
RA
Clear
112352483ms
Blood volume: 5880 ml SAP: 114/ 58(79)
PAP: 28/7(12) mmHg
CVP: 2,9 mmHg
Cardiac output: 5,15 l/min
Sound
Error control
Patient information
Turn off ventilation

Left ventricular performance assessed by echocardiographic automated border detection and arterial pressure

ANDRE Y. DENAULT,[1] JOHN GORCSAN III,[2] WILLIAM A. MANDARINO,[3]
MARY JEAN KANCEL,[1] AND MICHAEL R. PINSKY[1]
[1]*Division of Critical Care Medicine,* [2]*Department of Cardiology, and* [3]*Department of Cardiothoracic Surgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania 15261*

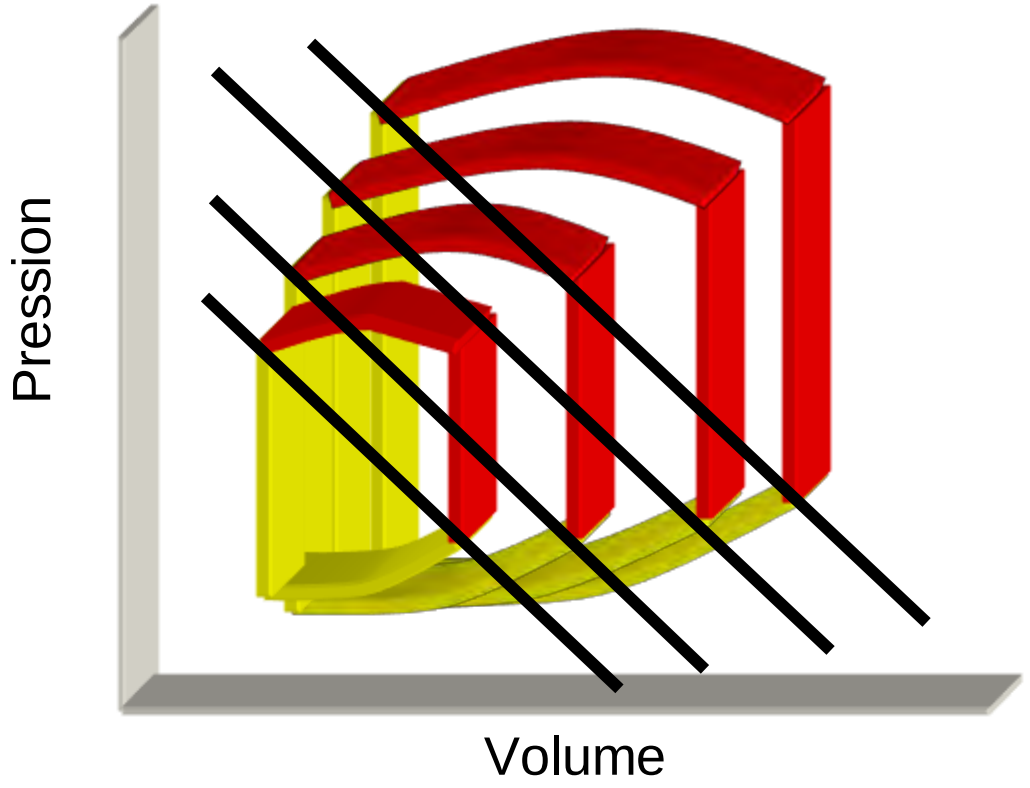


Am J Physio 1997


Run Pause Stop
Aplysia CardioVascular Lab Advanced - [Pressure-volume loops]
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Menu
Heart rate 72 /min
Blood volume 5880 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2,80 Min 0,05
Contractility Stiffness Right ventricle Max 0,70 Min 0,04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0,87 PRU
PVR 0,097 PRU
Venous compliance is 253 ml/mmHg
Arterial Stiffness 0,73 mmHg/ml
Pericardial and septal settings Pericardium and septum
Autoregulation Autoregulation
Brain
72
mmHg
100
50
0
100
ml
mmHg
10
5
0
100
ml
↑ résistance vasculaire
ml
RV
Marks
PV-relations
LA
RA
Clear
Blood volume: 5880 ml SAP: 112/ 58(77)
PAP: 29/7(12) mmHg
CVP: 2,3 mmHg
Cardiac output: 5,12 l/min
Sound
Error control
Patient information
Turn off ventilation

Courbe pression-volume

Élastance artérielle (Ea)

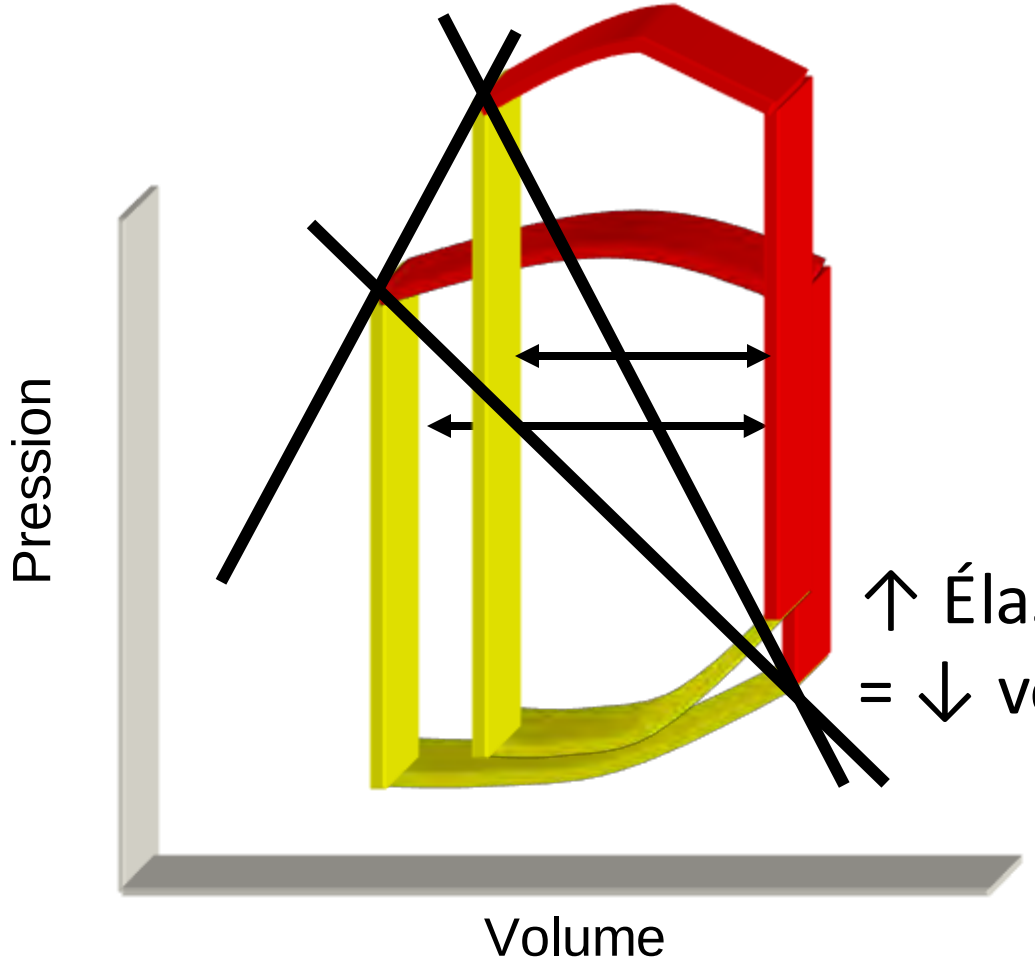


Efficacité ♥ maximale si
Ees/Ea = 1.0-2.0

LV Ea = PTSVG/VE

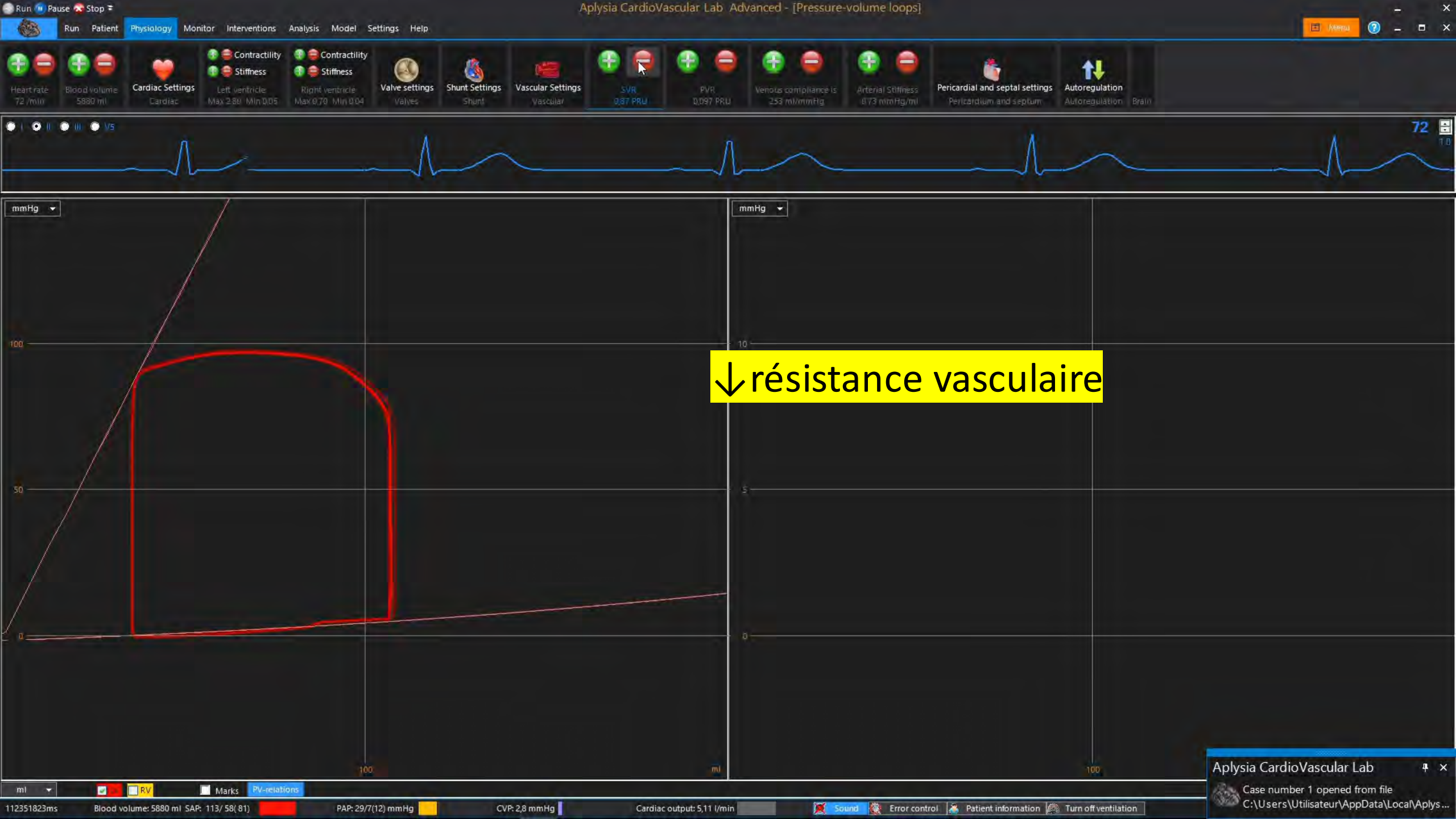
https://www.khanacademy.org/science/health-and-medicine/circulatory-system/changing-the-pv-loop-nm/v/getting-ea-arterial-elastance-from-the-pv-loop

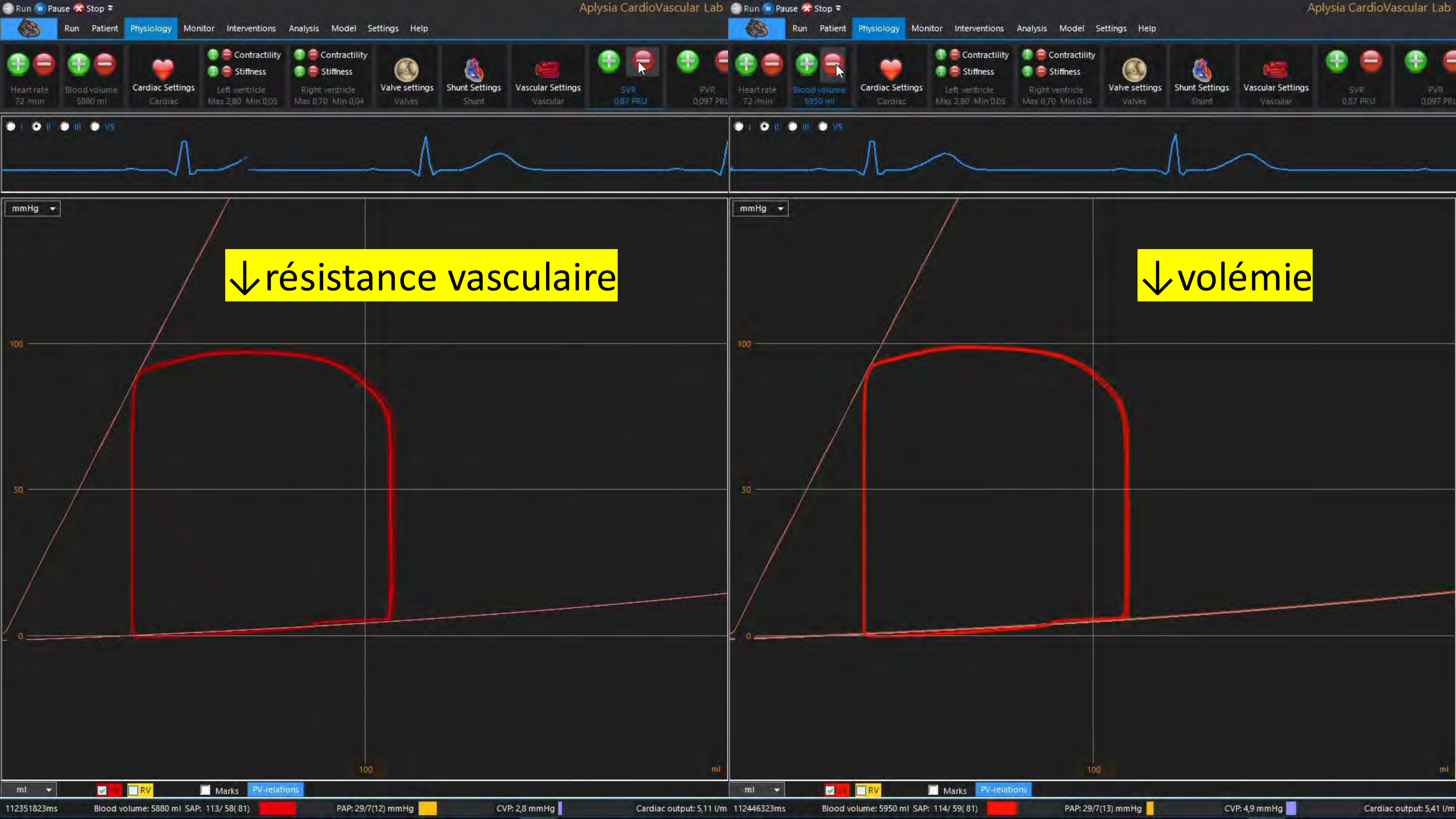
Sténose aortique



↑ Élastance artérielle (Ea)
= ↓ volume d'éjection

LV Ea = PTSVG/VE


Run Pause Stop
Aplysia CardioVascular Lab Advanced - [Pressure-volume loops]
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Menu
Heart rate 72 /min
Blood volume 5880 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2.80 Min 0.05
Contractility Stiffness Right ventricle Max 0.70 Min 0.04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0.87 PRU
PVR 0.097 PRU
Venous compliance is 253 ml/mmHg
Arterial Stiffness 0.73 mmHg/ml
Pericardial and septal settings Pericardium and septum
Autoregulation Autoregulation
Brain
I II III V5
72
1.0
mmHg
100
50
0
100
ml
mmHg
10
5
0
100
↓résistance vasculaire
ml
RV
Marks
PV-relations
112351823ms
Blood volume: 5880 ml SAP: 113/ 58(81)
PAP: 29/7(12) mmHg
CVP: 2,8 mmHg
Cardiac output: 5,11 l/min
Sound
Error control
Patient information
Turn off ventilation
Aplysia CardioVascular Lab
Case number 1 opened from file
C:\Users\Utilisateur\AppData\Local\Aplys...


Run Pause Stop
Aplysia CardioVascular Lab
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Heart rate 72 /min
Blood volume 5880 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2,80 Min 0,05
Contractility Stiffness Right ventricle Max 0,70 Min 0,04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0,87 PRU
PVR 0,097 PRU
I II III V5
mmHg
↓résistance vasculaire
100
50
0
100
ml
ml RV Marks PV-relations
112351823ms Blood volume: 5880 ml SAP: 113/ 58(81) PAP: 29/7(12) mmHg CVP: 2,8 mmHg Cardiac output: 5,11 l/m
Run Pause Stop
Aplysia CardioVascular Lab
Run Patient Physiology Monitor Interventions Analysis Model Settings Help
Heart rate 72 /min
Blood volume 5950 ml
Cardiac Settings Cardiac
Contractility Stiffness Left ventricle Max 2,80 Min 0,05
Contractility Stiffness Right ventricle Max 0,70 Min 0,04
Valve settings Valves
Shunt Settings Shunt
Vascular Settings Vascular
SVR 0,87 PRU
PVR 0,097 PRU
I II III V5
mmHg
↓volémie
100
50
0
100
ml
ml RV Marks PV-relations
112446323ms Blood volume: 5950 ml SAP: 114/ 59(81) PAP: 29/7(13) mmHg CVP: 4,9 mmHg Cardiac output: 5,41 l/m

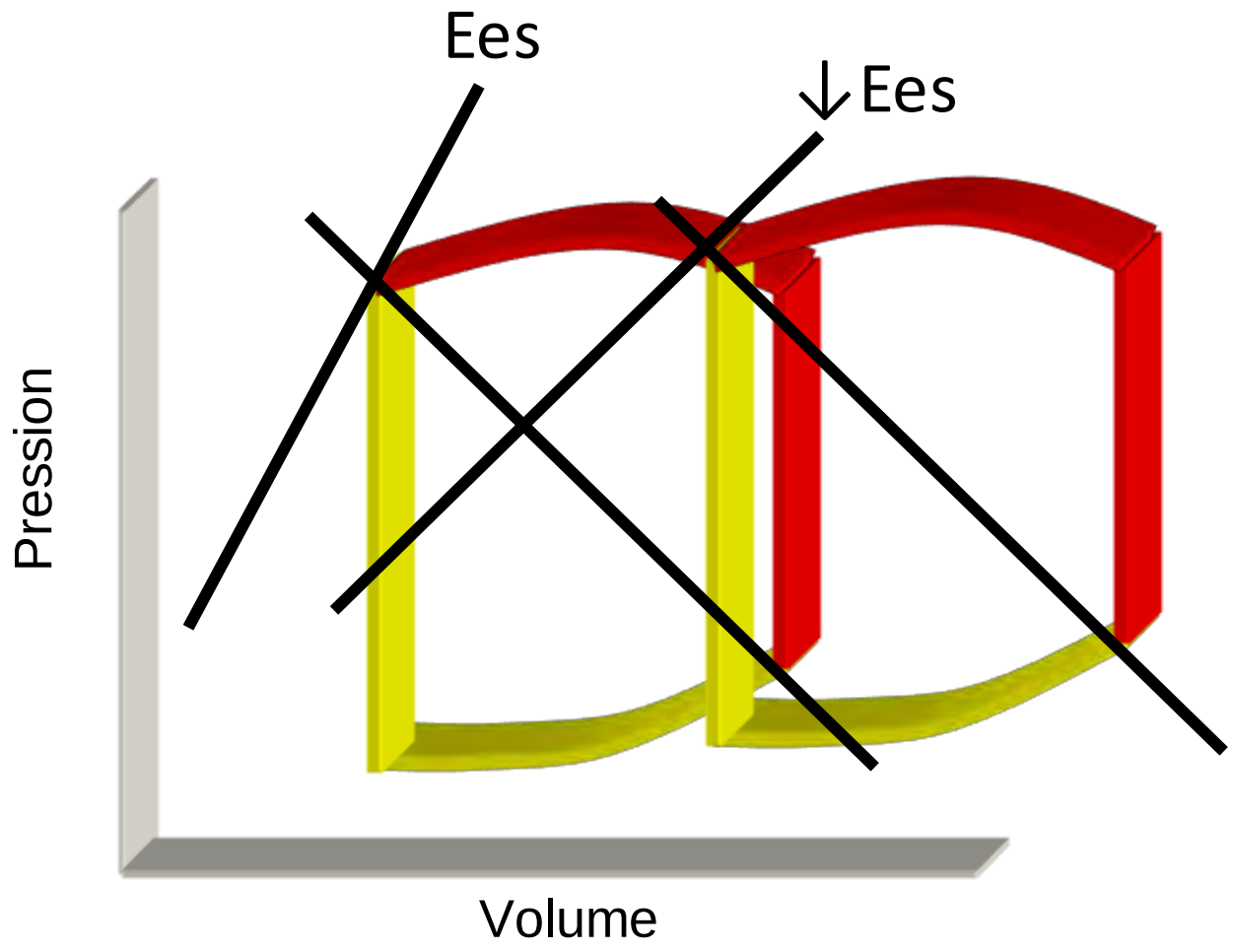
Point clé #2: hypotension

↓NIRS
↓ETCO2

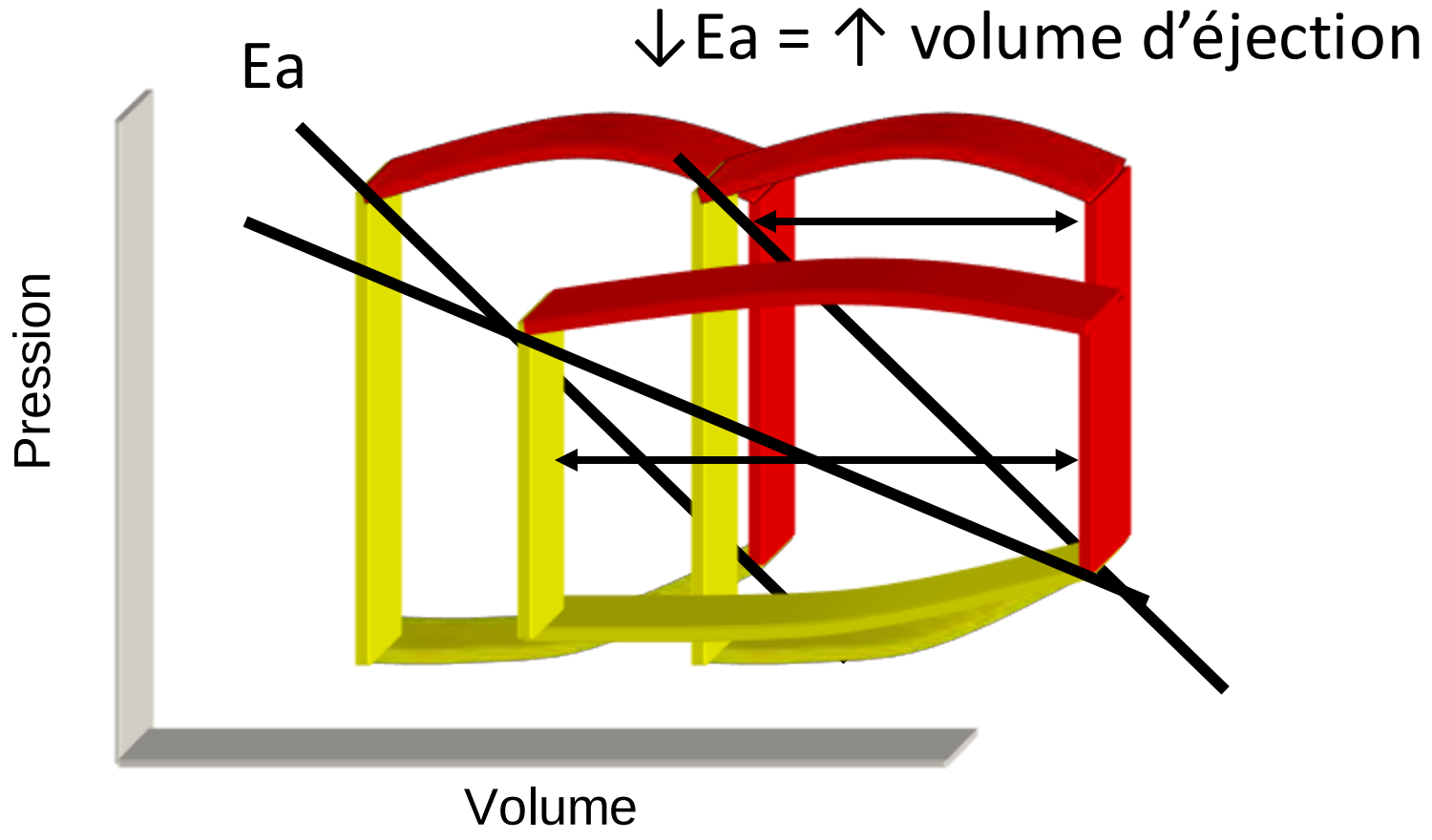
≠

NIRS inchangé
ETCO2 inchangé

Cardiomyopathie dilatée



Cardiomyopathie dilatée

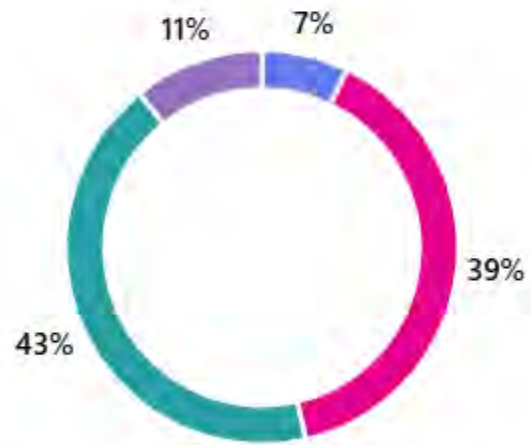


En résumé

- La courbe pression-volume permet de comprendre la fonction cardiaque
- Cette compréhension nécessite une mesure de pression et une mesure (ou estimation) du volume par échocardiographie
- Le couplage ventriculo-artériel est l'étalon-or de la fonction cardiaque gauche et droite
- La cardiomyopathie dilatée et la fonction droite sont très dépendant de la post-charge

1. Courbe pression-volume (0 point)

A	2
B	11
C	12
D	3

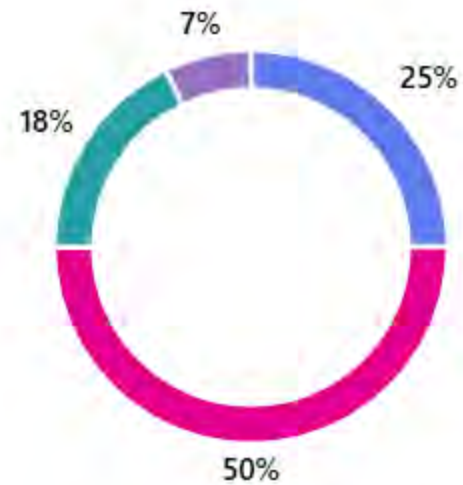


2. Fraction d'éjection (0 point)

A	0
B	5
C	10
D	13

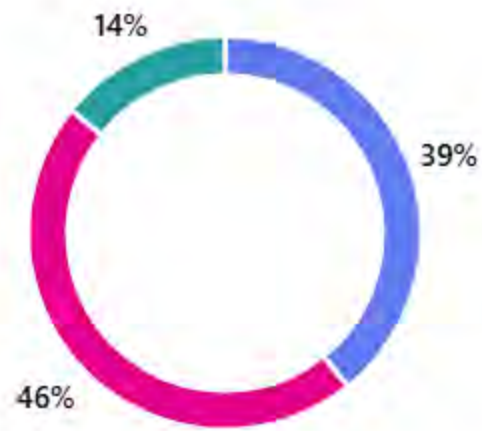
3. Travail ventriculaire (0 point)

A	7
B	14
C	5
D	2



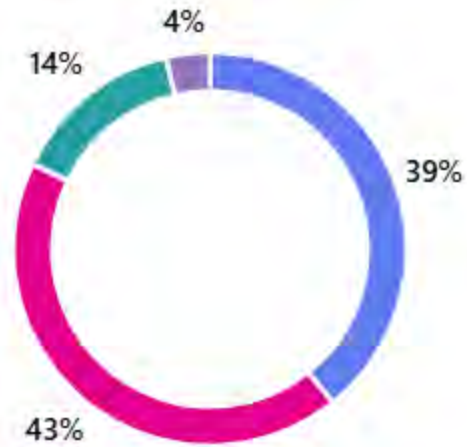
4. Élastance ventriculaire (0 point)

A	11
B	13
C	4
D	0



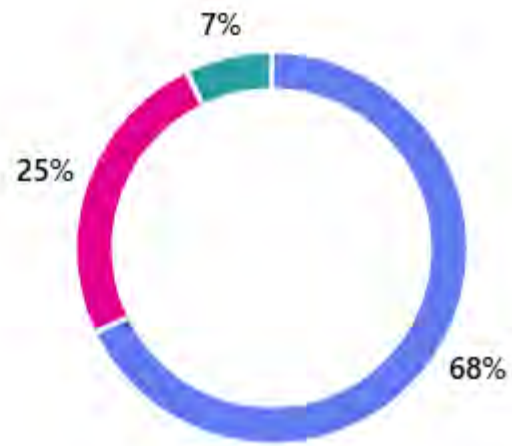
5. Élastance artérielle (0 point)

A	11
B	12
C	4
D	1

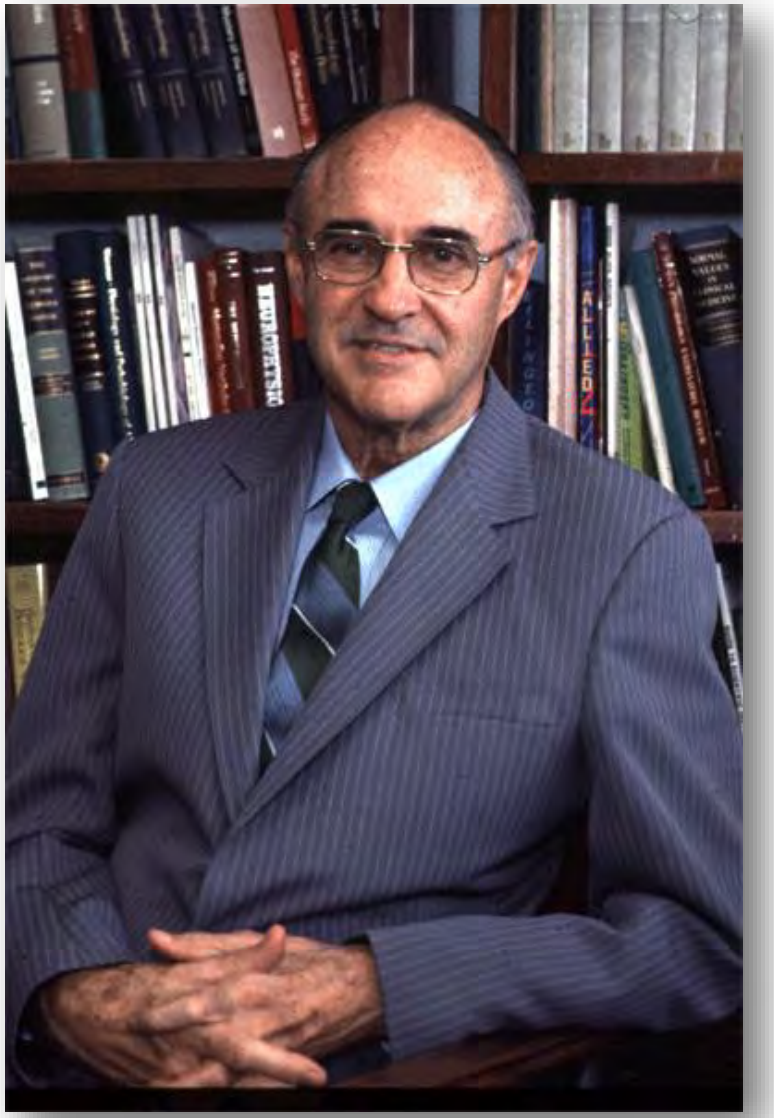


6. Couplage ventriculo-artériel (0 point)

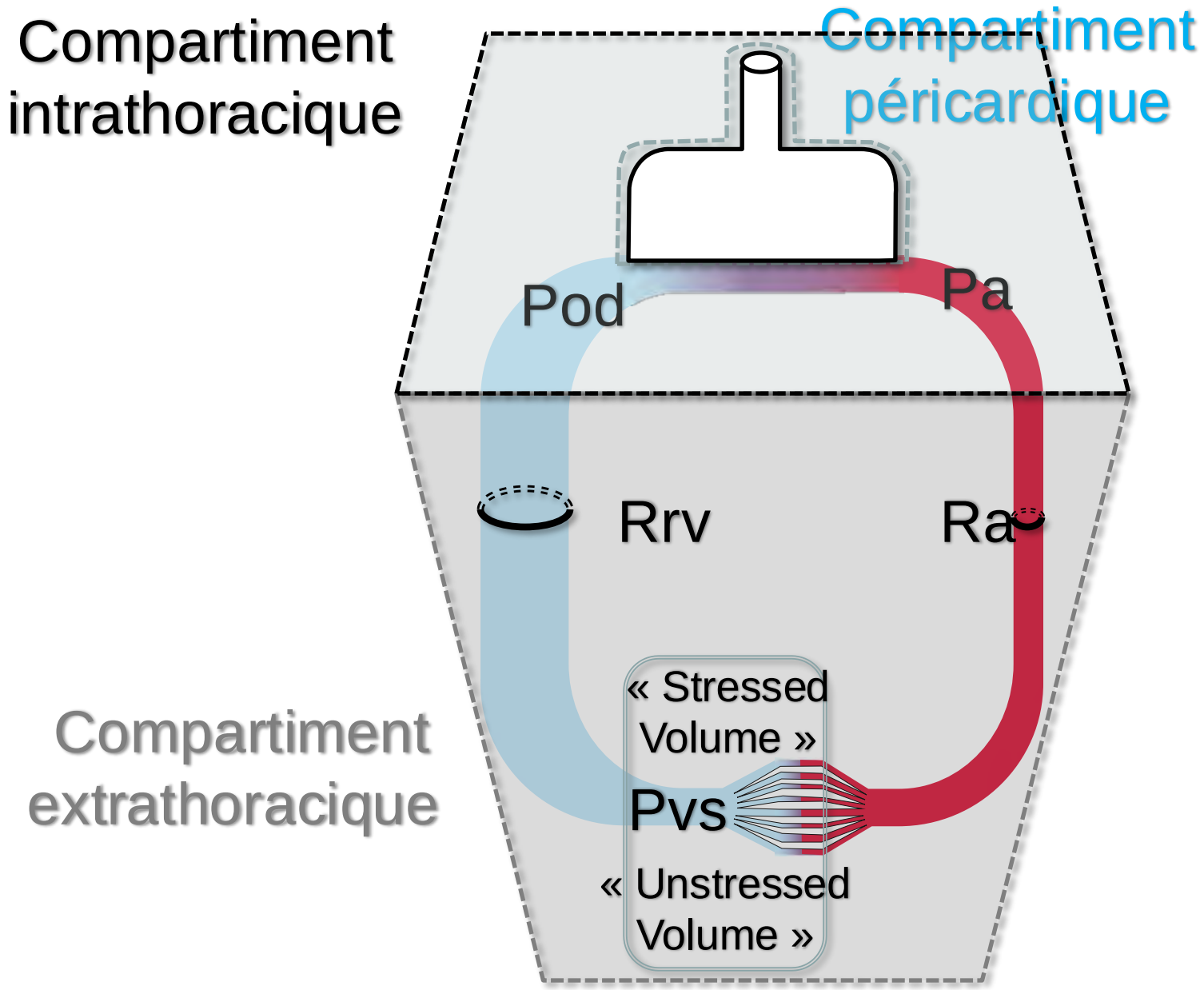
A	19
B	7
C	2
D	0



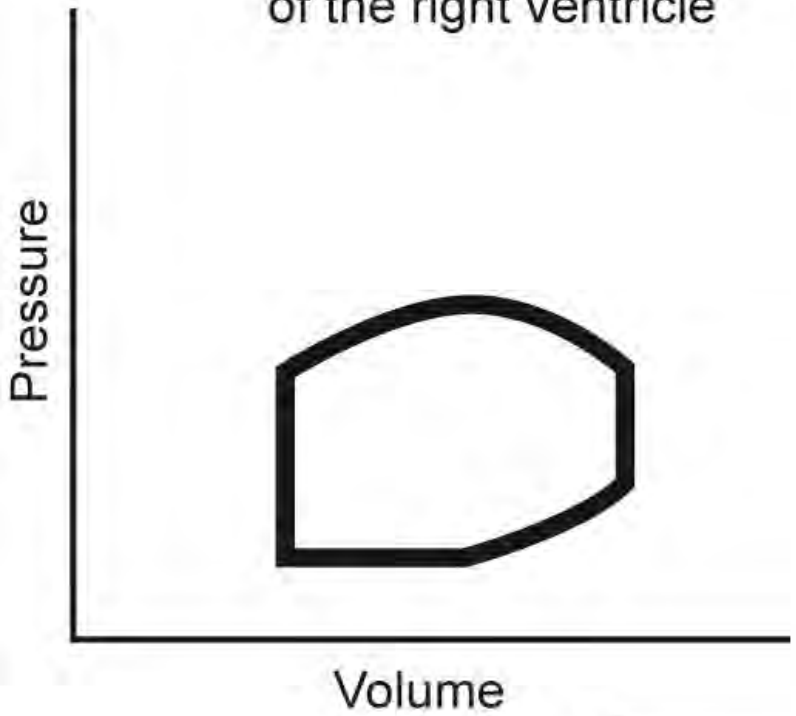
Arthur C. Guyton



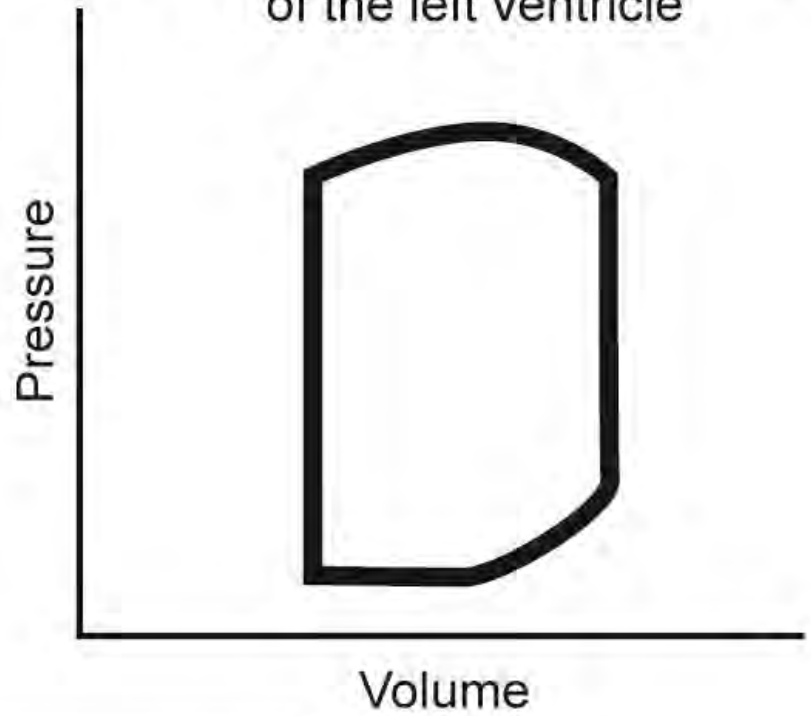
1919 - 2003


Compartiment intrathoracique
Compartiment péricardique
Pod
Pa
Rrv
Ra
Compartiment extrathoracique
« Stressed Volume »
Pvs
« Unstressed Volume »

Pressure-volume relationship of the right ventricle



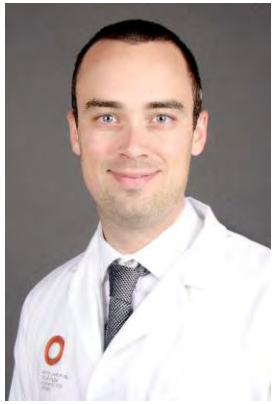
Pressure-volume relationship of the left ventricle



ORIGINAL BASIC SCIENCE REPORT

OPEN

Longitudinal Validation of Right Ventricular Pressure Monitoring for the Assessment of Right Ventricular Systolic Dysfunction in a Large Animal Ischemic Model

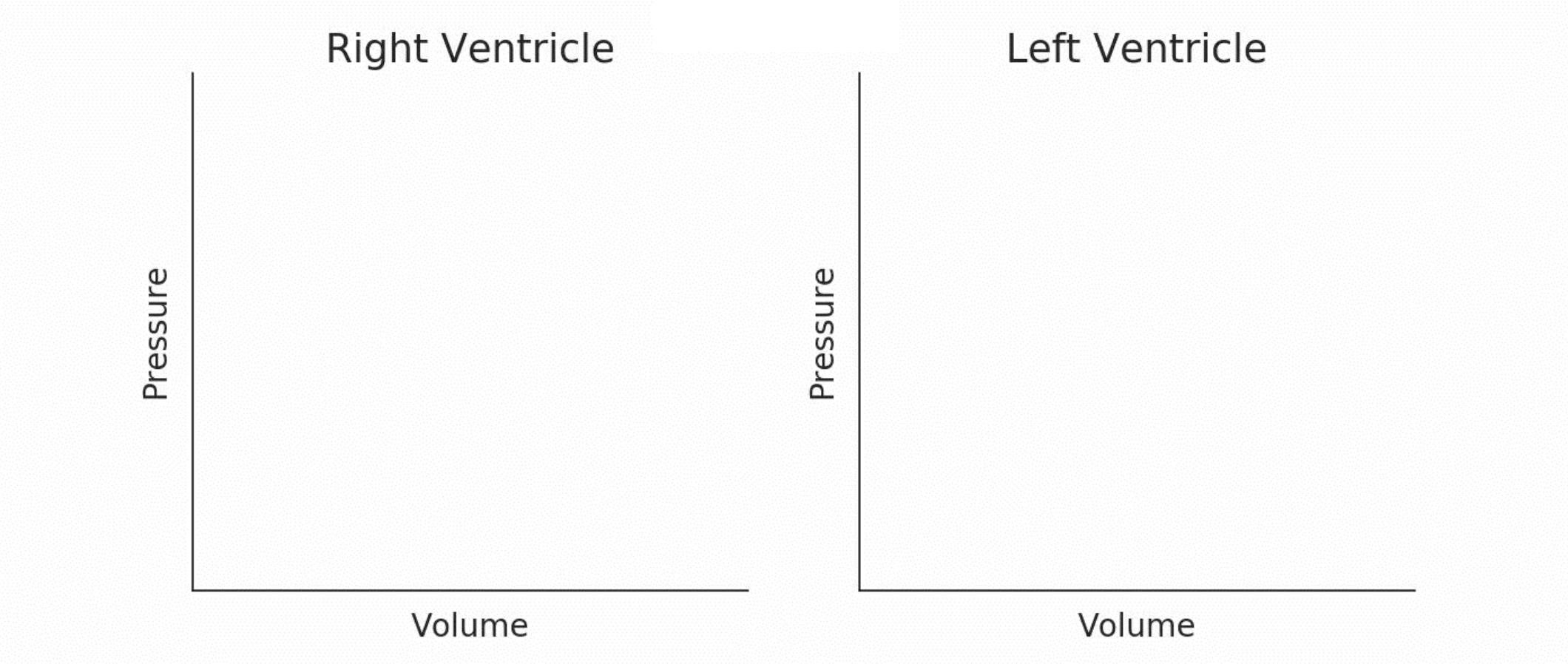


Créer un modèle animal de défaillance VD par microembolization de la coronaire droite.

Corréler les mesures obtenues par cathéter de conductance et courbe pression-volume biventriculaire au mesures de pression du VD par cathéter de l'artère pulmonaire.

Couture EJ et al . Crit Care Explor. 2023;5(1):e0847.

Occlusion de la coronaire droite (modèle animal)



Current Cardiology Reports (2024) 26:521–537
https://doi.org/10.1007/s11886-024-02052-3

CONGENITAL HEART DISEASE (RA KRASUSKI AND G FLEMING, SECTION EDITORS)

Right Ventricle-Pulmonary Artery Coupling in Patients Undergoing Cardiac Interventions

Crosby Culp[1] · Jon Andrews[1] · Katherine Wang Sun[1] · Kendall Hunter[2] · Anne Cherry[1] · Mihai Podgoreanu[1] · Alina Nicoara[1]

Déterminants du retour veineux

$$RV = \frac{\text{Gradient de pression}}{\text{Résistance au RV}} = \frac{Pvs - Pod}{Rrv}$$

↓ Retour veineux si:

1-↓ Pvs: hypovolémie, vasodilatation

2-↑ Pod: dysfonction systolique ventriculaire gauche et droite

dysfonction diastolique ventriculaire gauche et droite

obstructions des valves et des chambres de chasse

embolies pulmonaires

hypoxie et hypercapnie

3-↑ Rrv: obstruction intrinsèque ou extrinsèque (syndrome du compartiment) (péricardique, médiastinal, thoracique, abdominal)

Déterminants du retour veineux

$$RV = \frac{\text{Gradient de pression}}{\text{Résistance au RV}} = \frac{Pvs - Pod}{Rrv}$$

↓ Retour veineux si:

Ou une combinaison de 2 ou 3 mécanismes

1-↓ Pvs: Choc hémorrhagique

Choc distributif

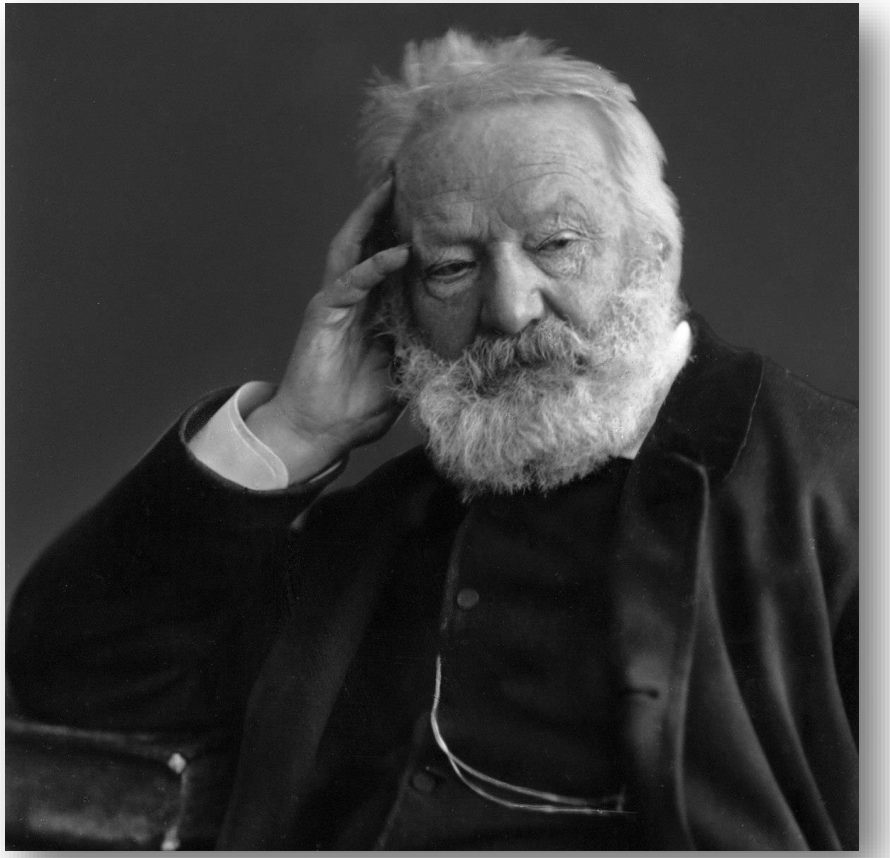
2-↑ Pod: Choc cardiogénique

3-↑ Rrv: Choc obstructif

État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

« On résiste à l'invasion des armées; on ne résiste pas à l'invasion des *idées*. »



The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

CRITICAL CARE MEDICINE

Simon R. Finfer, M.D., and Jean-Louis Vincent, M.D., Ph.D., *Editors*

Circulatory Shock

Jean-Louis Vincent, M.D., Ph.D., and Daniel De Backer, M.D., Ph.D.

Circulatory Shock

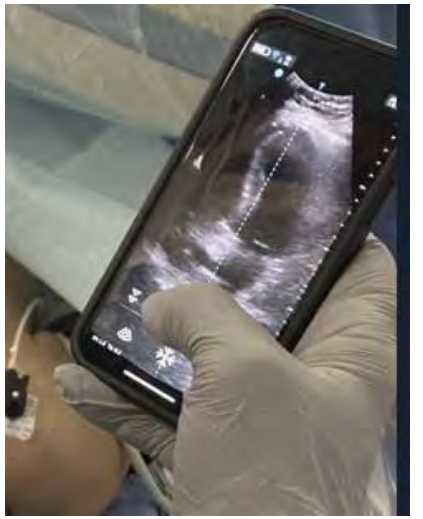
Jean-Louis Vincent, M.D., Ph.D., and Daniel De Backer, M.D., Ph.D.

tention, and peripheral edema. The diagnosis can be refined with point-of-care echocardiographic evaluation, which includes assessment for pericardial effusion, measurement of left and right ventricular size and function, assessment for respiratory variations in vena cava dimensions, and calculation of the aortic velocity–time integral, a measure of stroke volume. Whenever possible, focused echocardiography should be performed as soon as possible in any patient presenting with shock (Fig. 1A).[5,6]

The NEW ENGLAND JOURNAL of MEDICINE

Point-of-Care Ultrasonography

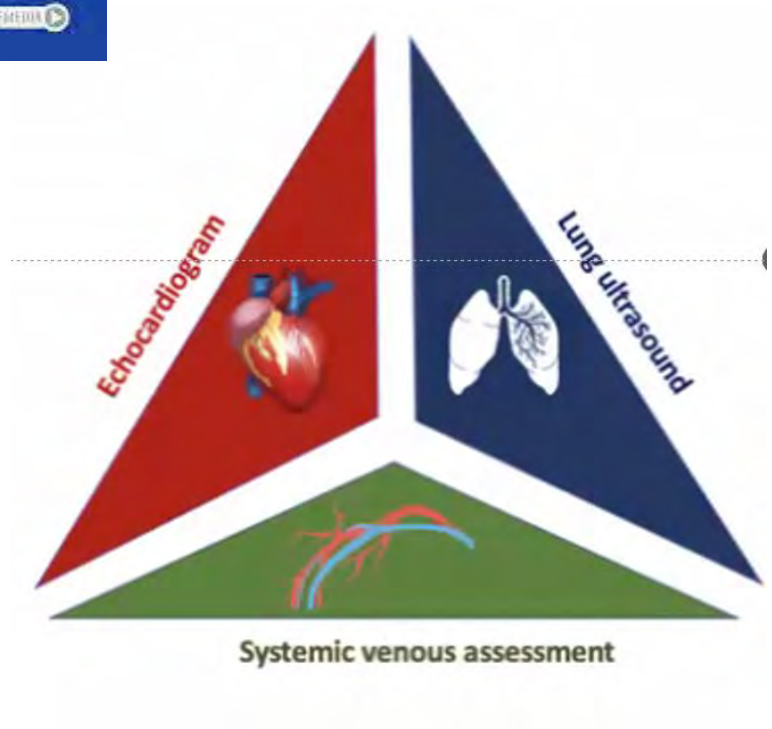
José L. Díaz-Gómez, M.D., Paul H. Mayo, M.D., and Seth J. Koenig, M.D.



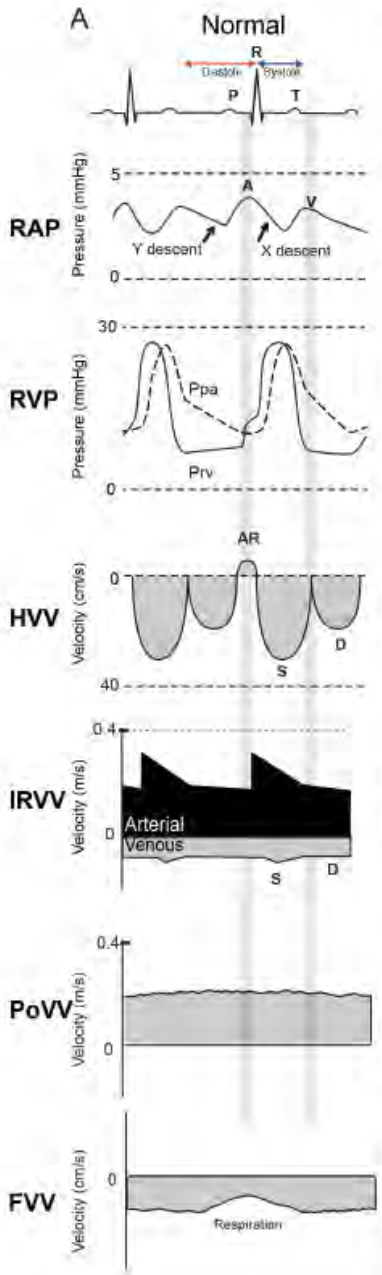
Unstable patient in hemodynamic suite

N Engl J Med 2021; 385: 1593-602. Doi: 10.1056/NEJMra19160627

Hatem Soliman, FRCP, FEACVI, FASE, FHEA
@EchoSoliman
Consultant Cardiac Intensive Care and ECMO @RBandH
| EACVI Secretary, Executive Board Member @escardio
| Senior Lecturer @kingscardio
| EchoFirst | ECMO | MCS



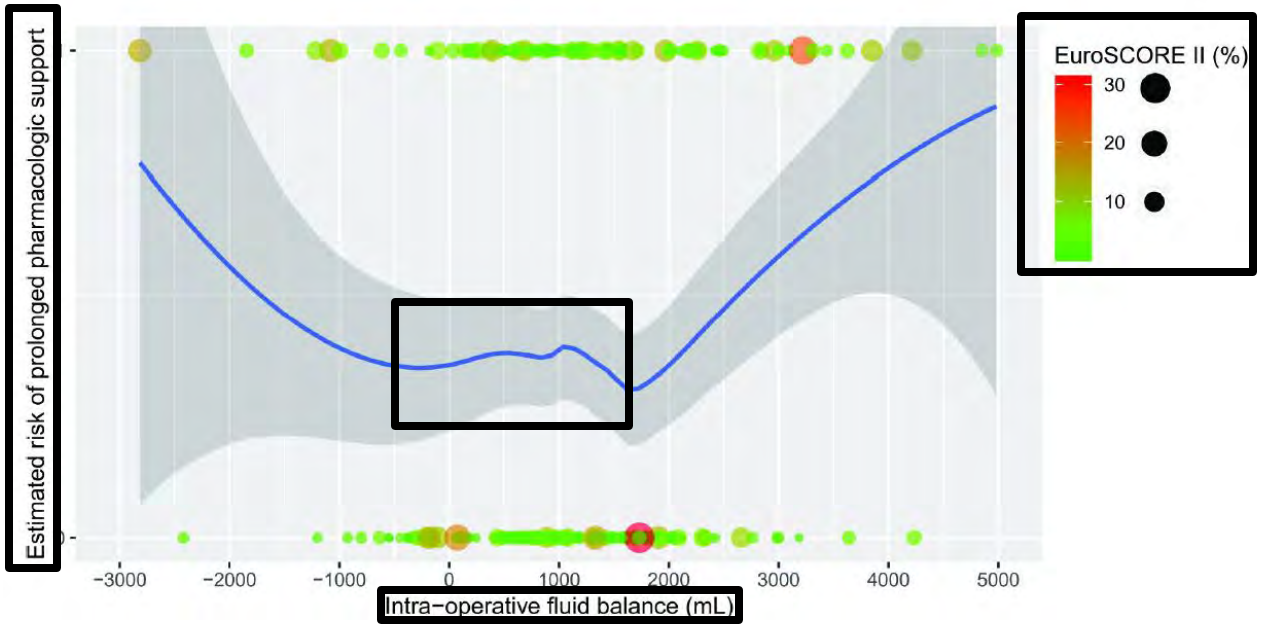
Georges Desjardins MD FRCPC



Assessment of venous congestion with ultrasound (27min)
https://vimeo.com/1060166019

Prolonged cardiovascular pharmacological support and fluid management after cardiac surgery

Loay Kontar[1,2,3], William Beaubien-Souligny[1,4], Etienne J. Couture[5], Matthias Jacquet-Lagrèze[1], Yoan Lamarche[6], Sylvie Levesque[7], Denis Babin[1], André Y. Denault[1,2]*



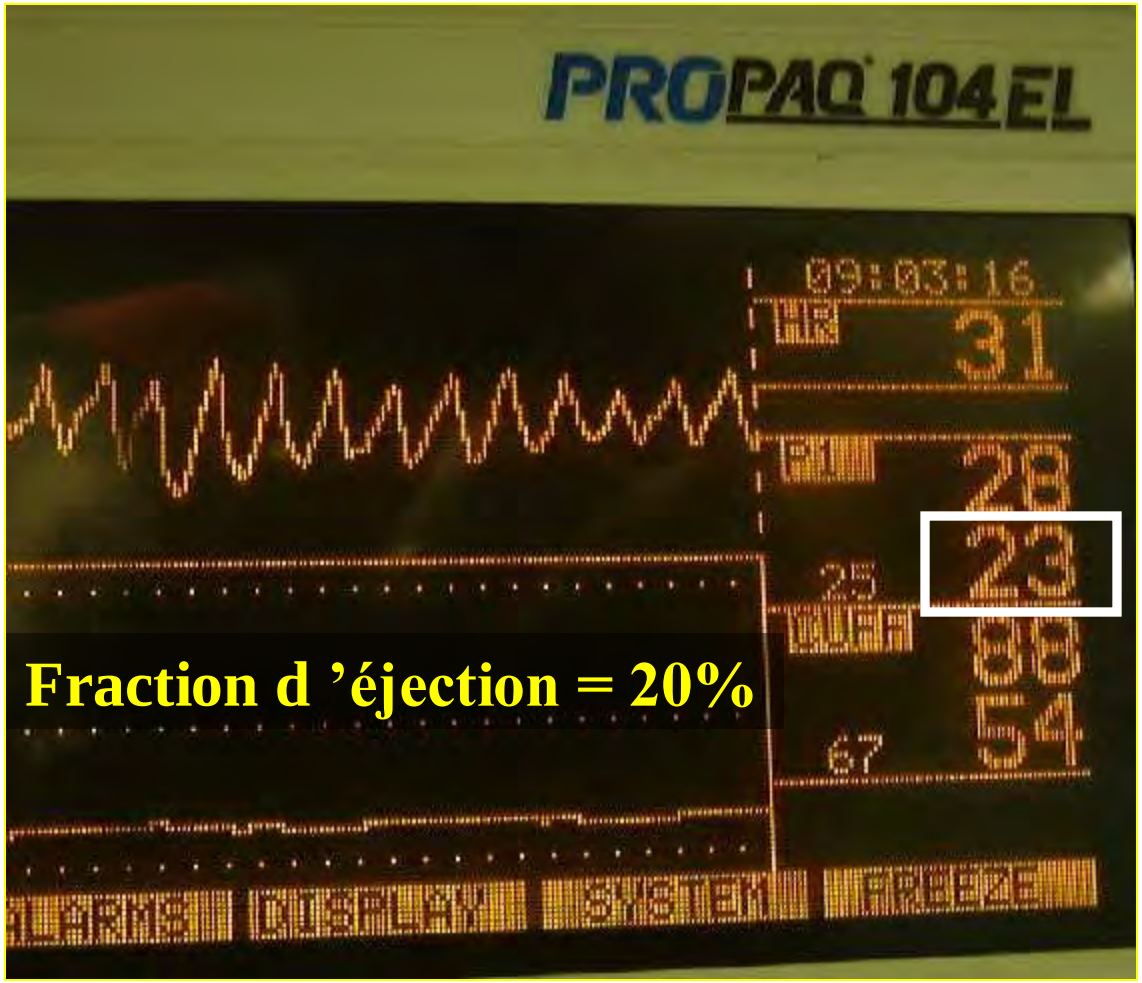
N = 247

PLoS One 2023; 18: e0285526. Doi: 10.1371/journal.pone.0285526

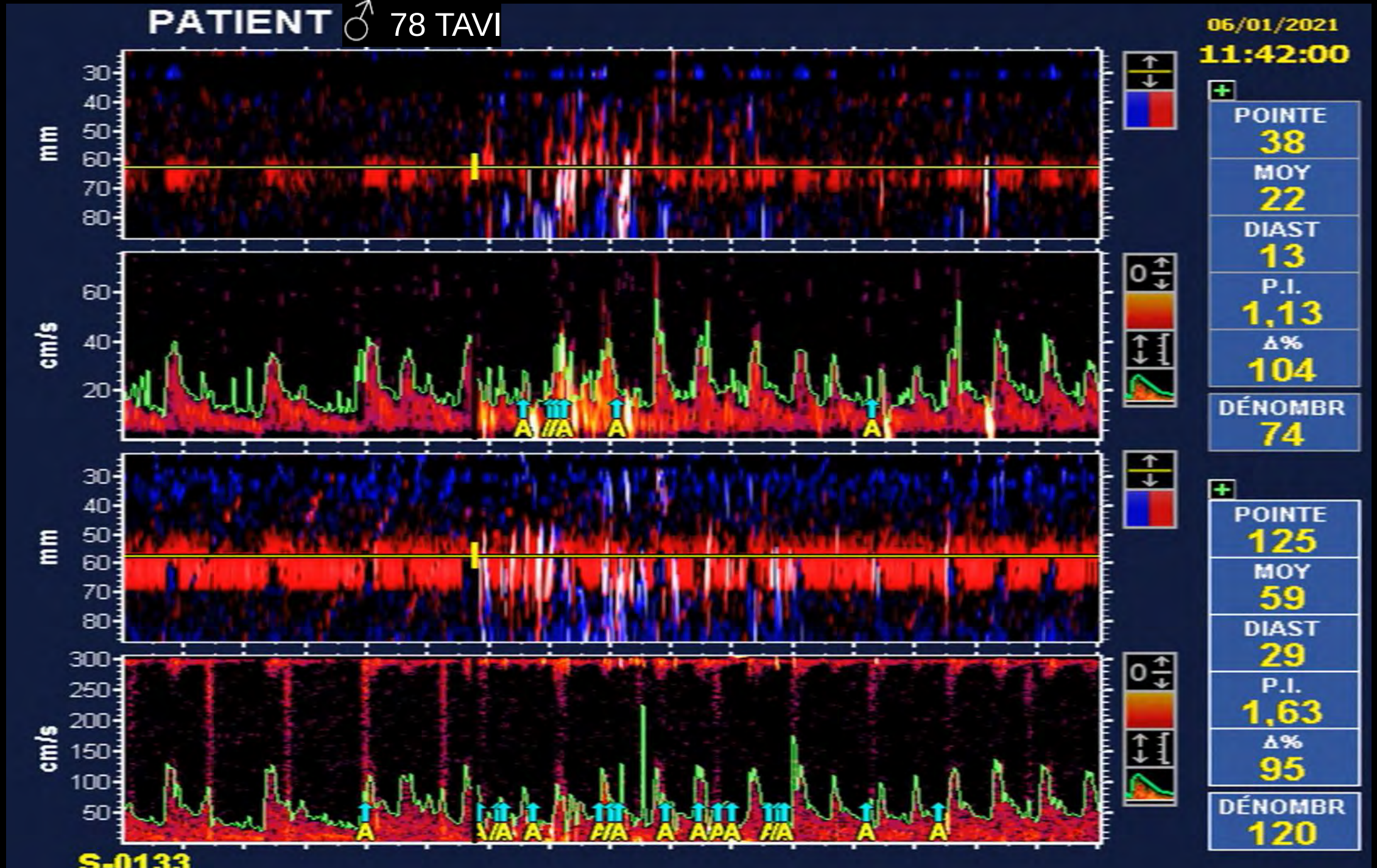
Lors de l'arrêt cardiaque chez un patient avec une fraction d'éjection à 20%:
lequel est vrai:

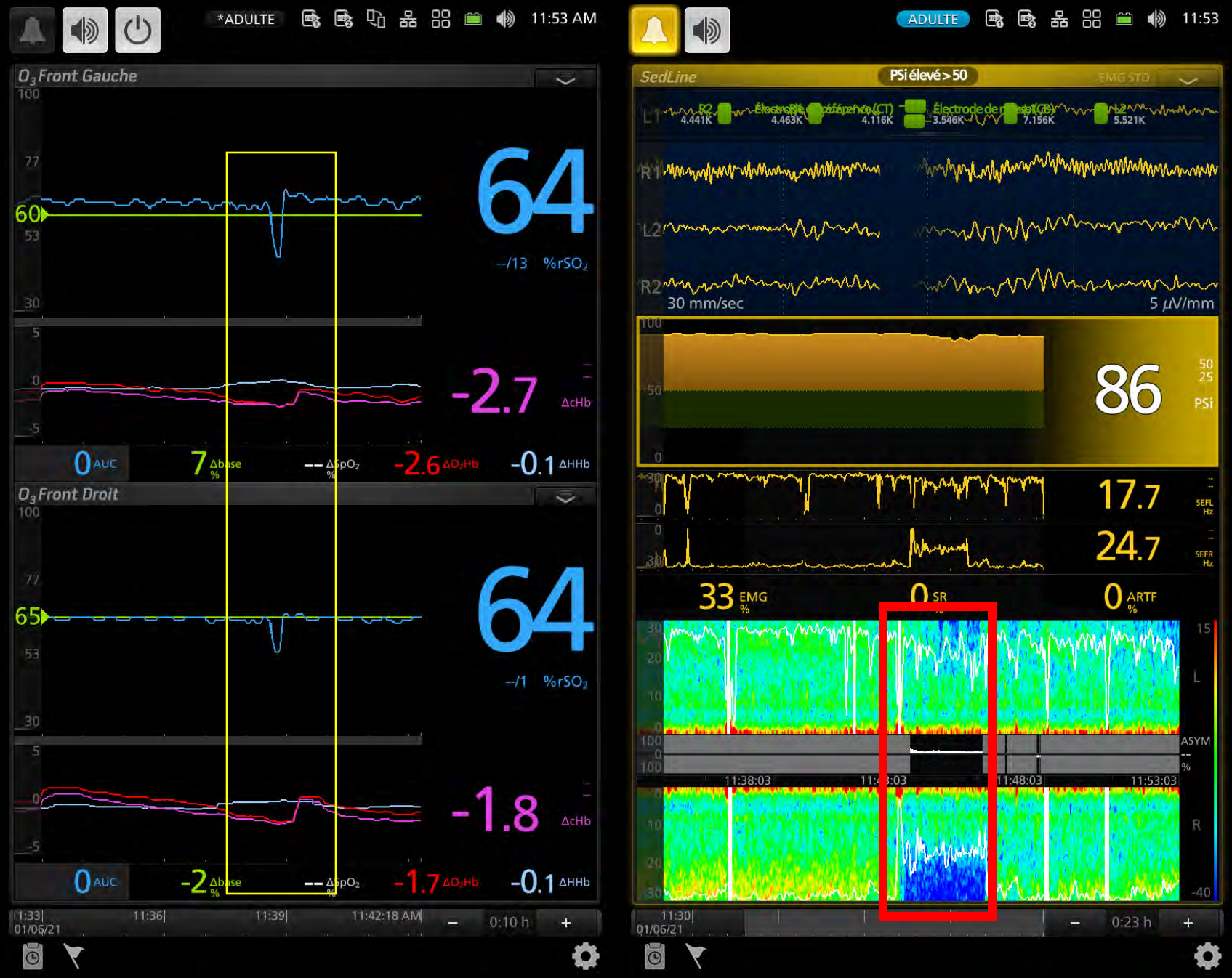
1-TAM = 0 mmHg et TVC = 0 mmHg
2-TAM = 10 mmHg et TVC = 0 mmHg
3-TAM = 20 mmHg et TVC = 20 mmHg
4-TAM = 0 mmHg et TVC = 20 mmHg
5-Ça dépends…..

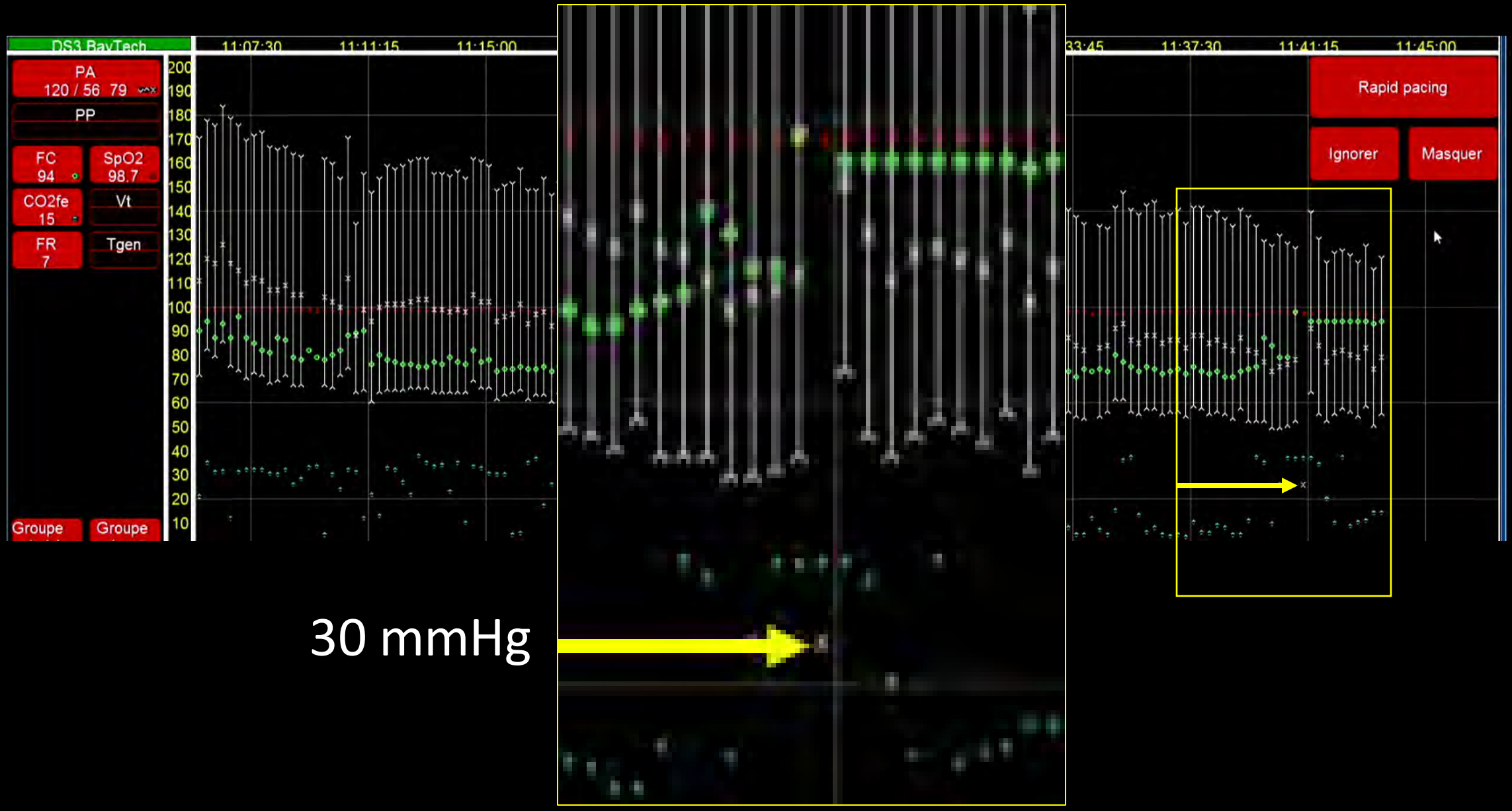
Femme de 70 ans, implantation de pace-défibrillateur



P1 = pression artérielle

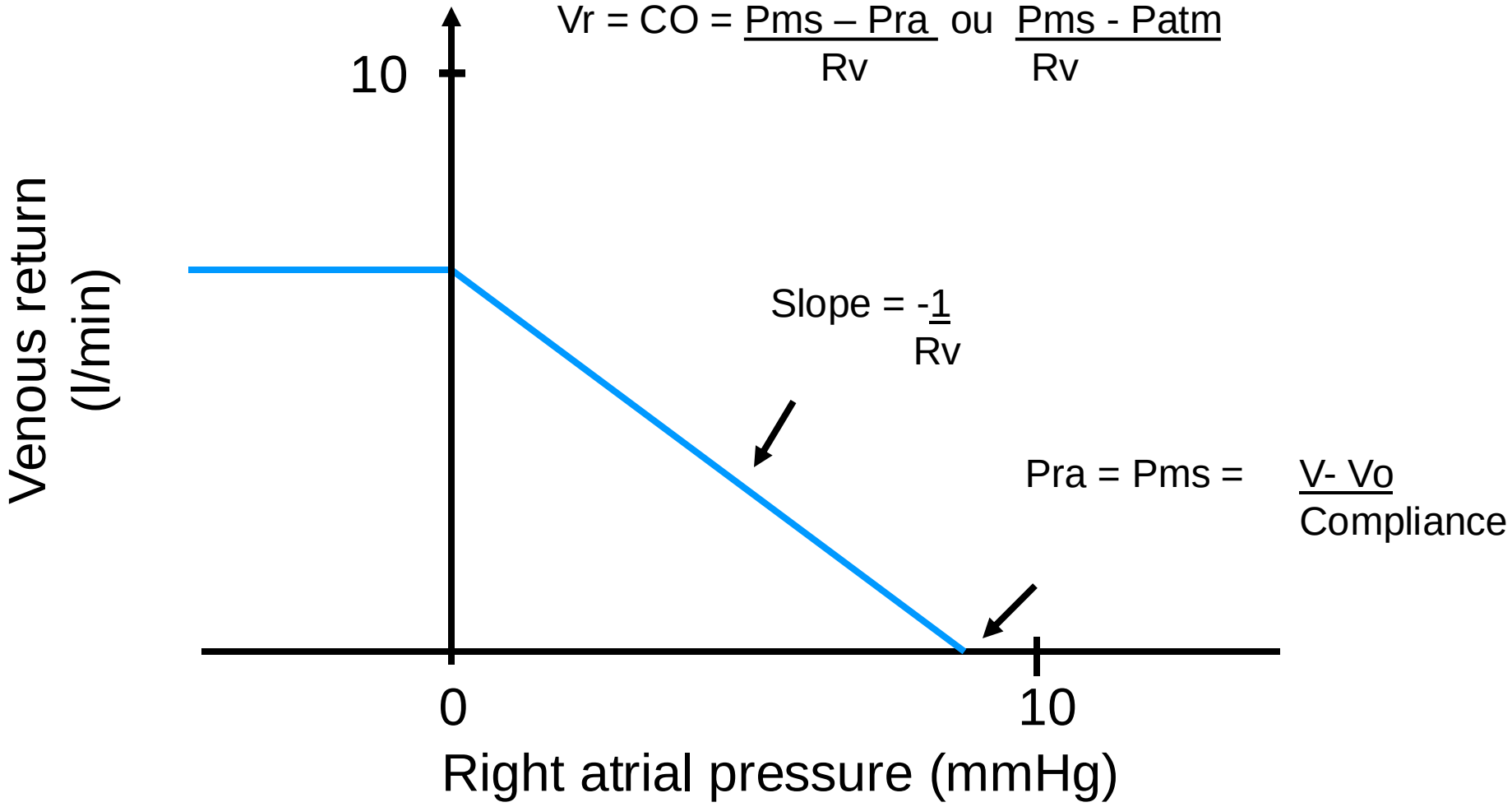

PATIENT ♂ 78 TAVI
06/01/2021
11:42:00
mm
cm/s
POINTE
38
MOY
22
DIAST
13
P.I.
1,13
Δ%
104
DÉNOMBR
74
POINTE
125
MOY
59
DIAST
29
P.I.
1,63
Δ%
95
DÉNOMBR
120
S-0133


*ADULTE
11:53 AM
O_3 Front Gauche
64
--/13 %rSO2
-2.7
ΔcHb
0 AUC
7 Δbase %
ΔSpO2
-2.6 ΔO2Hb
-0.1 ΔHHb
O_3 Front Droit
64
--/1 %rSO2
-1.8
ΔcHb
0 AUC
-2 Δbase %
ΔSpO2
-1.7 ΔO2Hb
-0.1 ΔHHb
11:33
11:36
11:39
11:42:18 AM
0:10 h
01/06/21
ADULTE
11:53
SedLine
PSi élevé > 50
EMG STD
30 mm/sec
5 µV/mm
86
PSi
17.7
SEFL Hz
24.7
SEFR Hz
33 EMG %
0 SR %
0 ARTF %
ASYM
11:38:03
11:48:03
11:53:03
11:30
0:23 h
01/06/21


DS3 BayTech
11:07:30
11:11:15
11:15:00
11:37:30
11:41:15
11:45:00
PA
120 / 56 79
PP
FC
94
SpO2
98.7
CO2fe
15
Vt
FR
7
Tgen
Groupe
Groupe
Rapid pacing
Ignorer
Masquer
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

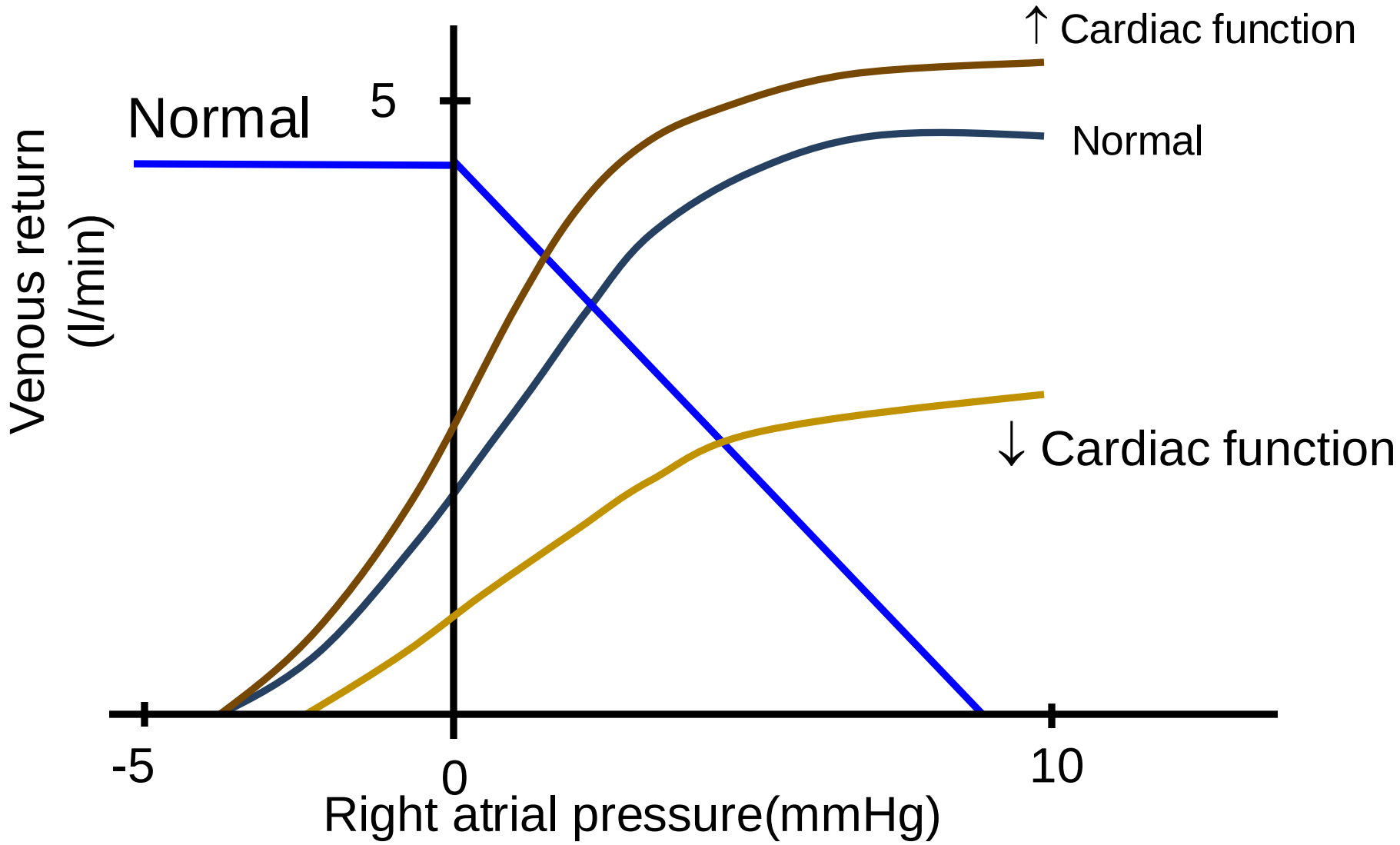
30 mmHg

La fonction cardiaque se situe un point de cette courbe



Adapated from: Jacobsohn et al Can J Anesth 1997 44:8 849-67

Cardiogenic shock



Adapated from: Jacobsohn et al Can J Anesth 1997 44:8 849-67

Retour veineux: points essentiels

Intensive Care Med (1998) 24: 651–653

EDITORIAL

S. Magder

More respect for the CVP

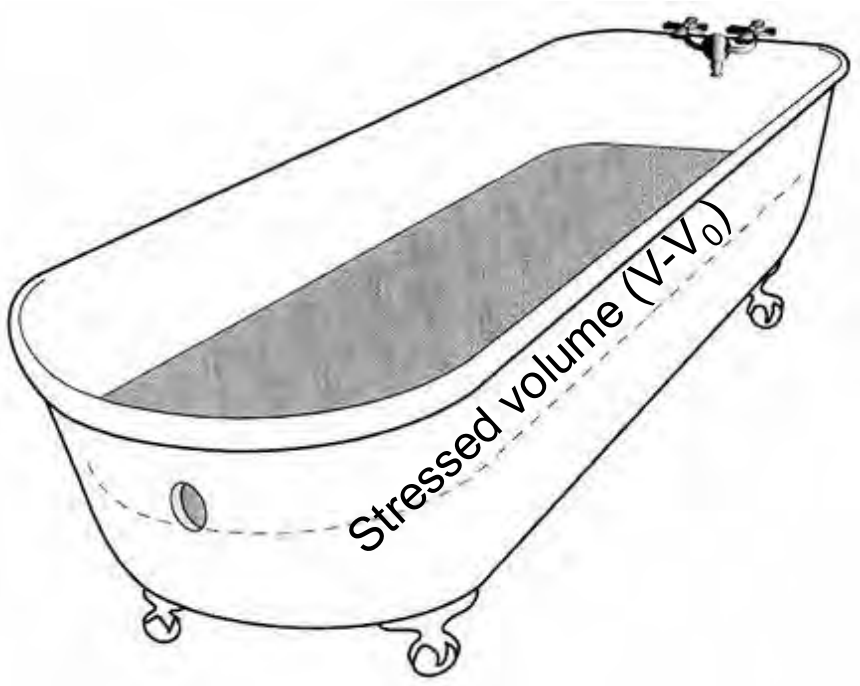
- Débit cardiaque = retour veineux
- Rôle du cœur = vider le réservoir veineux en abaissant la pression de l'oreillette droite
- Limite ou plateau à l'augmentation du retour veineux
- Si le cœur droit ne peut abaisser ses pressions = mauvais pronostique

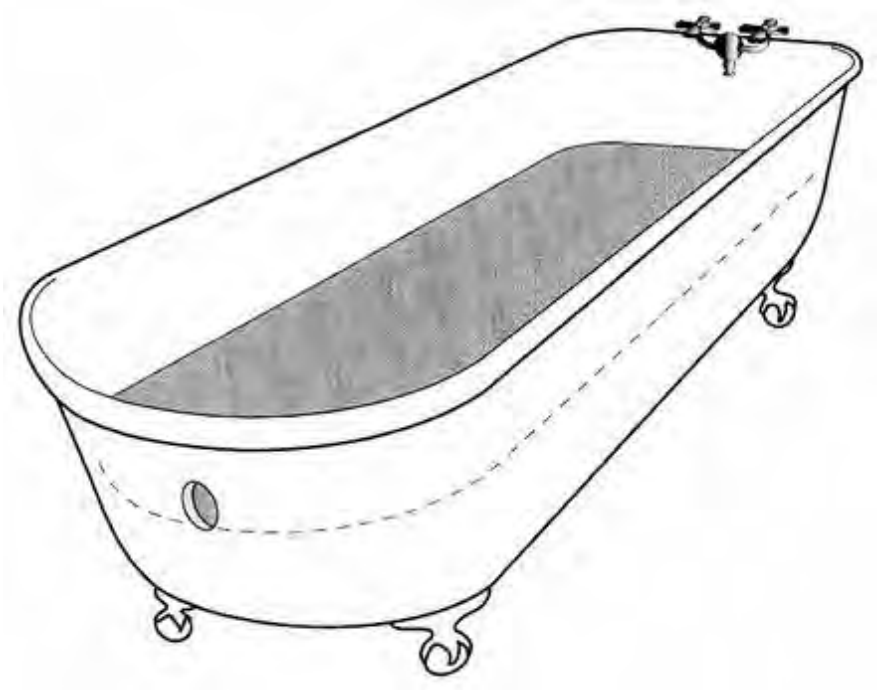
Intensive Care Med (1998) 24: 651–653

EDITORIAL

S. Magder

More respect for the CVP





1-Pression à la sortie du drain (pression de l'oreillette droite)
2-Quantité de volume au-dessus du drain (stressed volume)
3-Robinet (débit du cœur gauche)
4-Volume résiduel sous le drain (unstressed volume)
5-Pression exercée par le volume au-dessus du drain ou « stressed » volume (pression veineuse systémique)
6-Taille du bain (capacitance veineuse)
7-Quantité d'eau dans le bain:stressed et unstressed volume
8-Taille d'ouverture du drain (résistance au RV)
9-Hauteur du drain selon la fonction cardiaque droite

↓ du retour veineux si:

1-↓ Pvs: hypovolémie, vasodilatation

2-↑ Pod: dysfonction systolique ventriculaire gauche et droite

dysfonction diastolique ventriculaire gauche et droite

obstructions des valves et des chambres de chasse

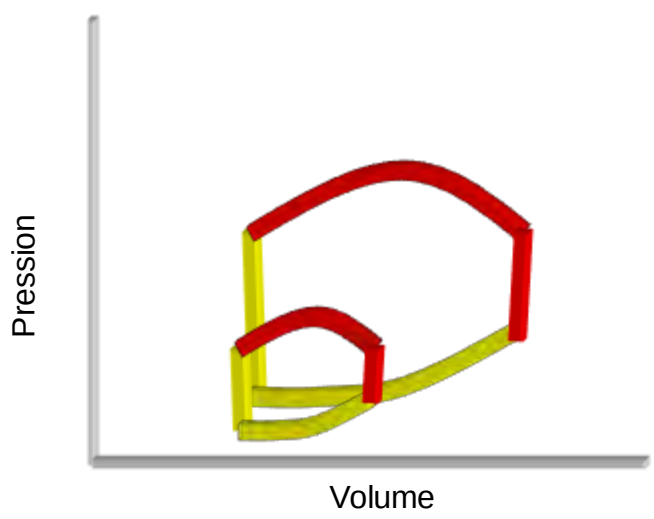
embolies pulmonaires

hypoxie et hypercapnie

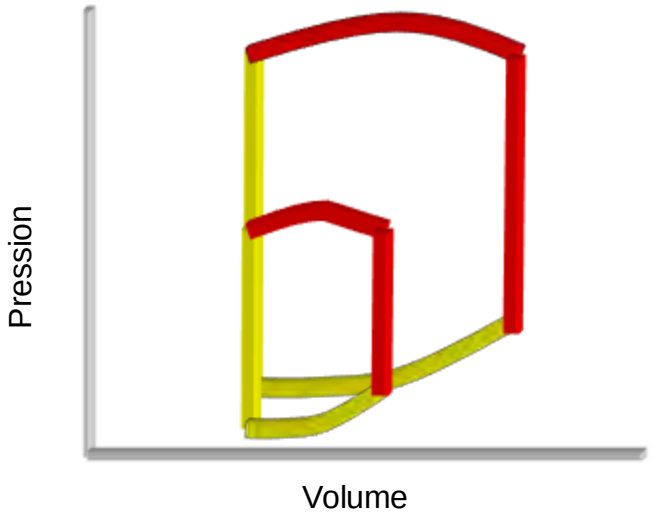
3-↑ Rrv: obstruction intrinsèque ou extrinsèque (syndrome du compartiment) (péricardique, médiastinal, thoracique, abdominal)

Baisse de la Pvs

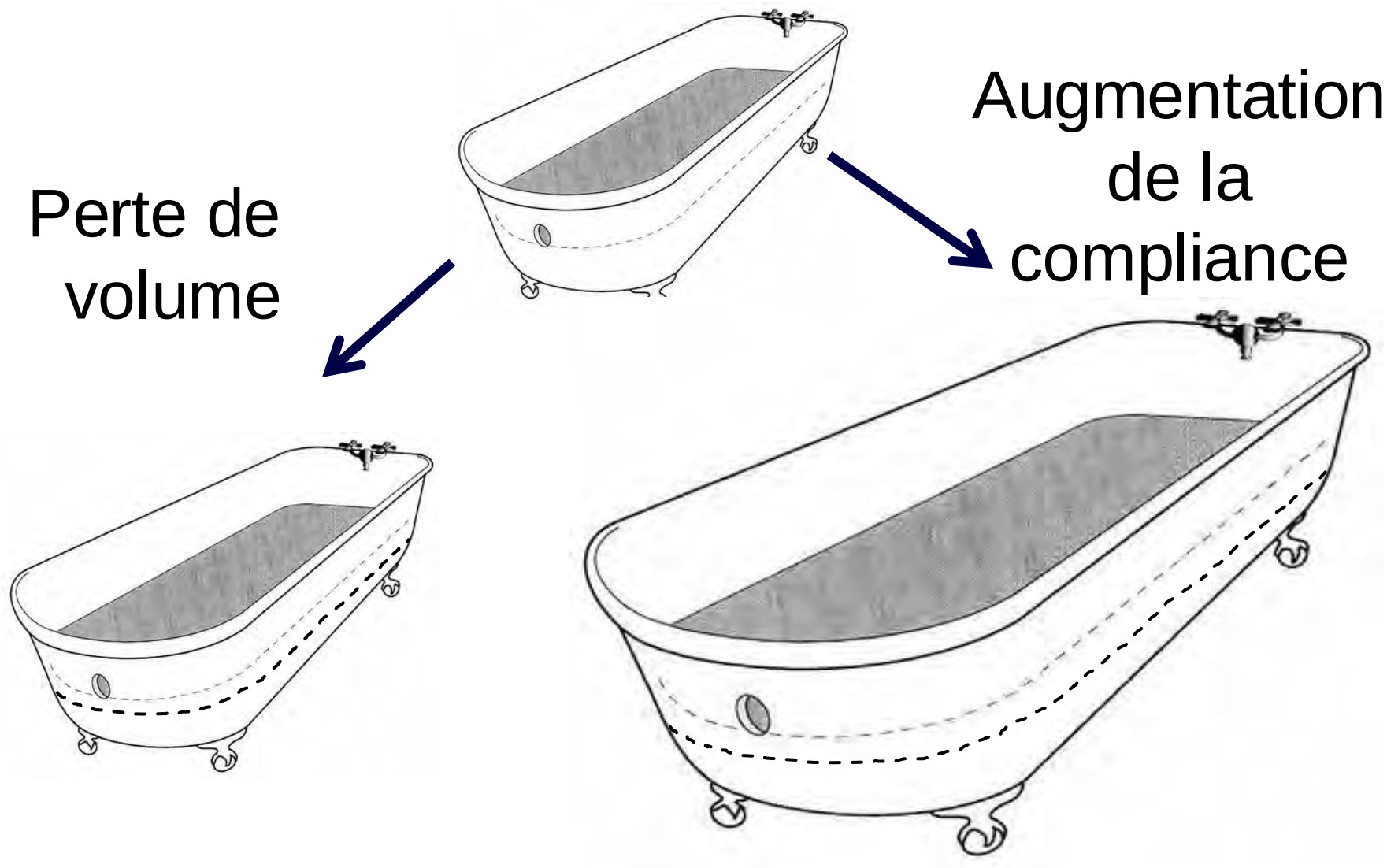
Courbe pression-volume ventriculaire droite



Courbe pression-volume ventriculaire gauche



$$Pvs = \frac{Volume}{Compliance}$$



Adapated from: Jacobsohn et al Can J Anesth 1997 44:8 849-67

↓ du retour veineux si:

1-↓ Pvs: hypovolémie, vasodilatation

2-↑ Pod: dysfonction systolique ventriculaire gauche et droite

dysfonction diastolique ventriculaire gauche et droite

obstructions des valves et des chambres de chasse

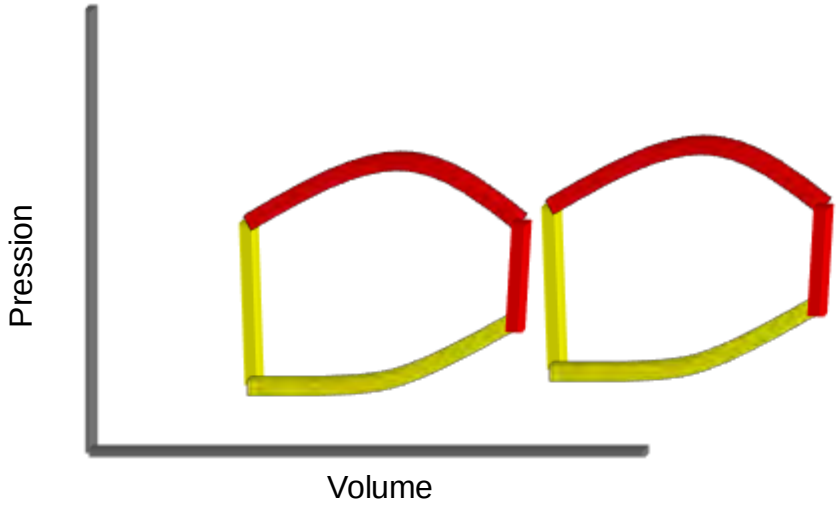
embolies pulmonaires

hypoxie et hypercapnie

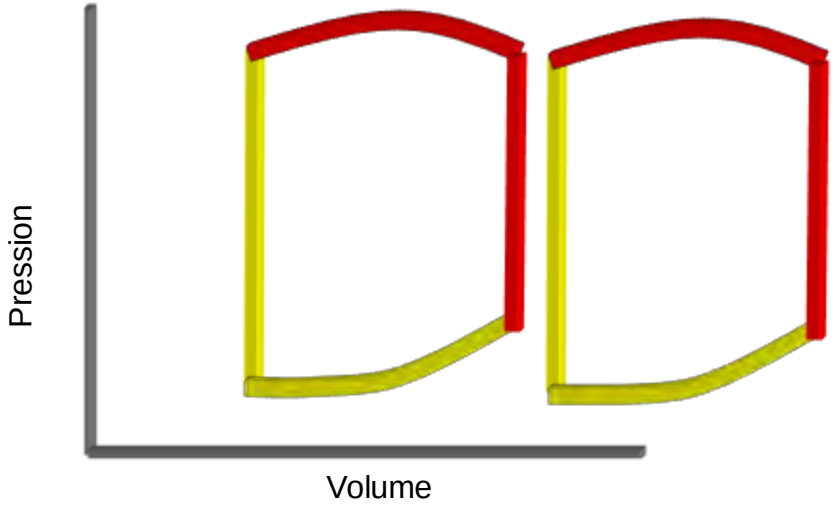
3-↑ Rrv: obstruction intrinsèque ou extrinsèque (syndrome du compartiment) (péricardique, médiastinal, thoracique, abdominal)

Dysfonction systolique

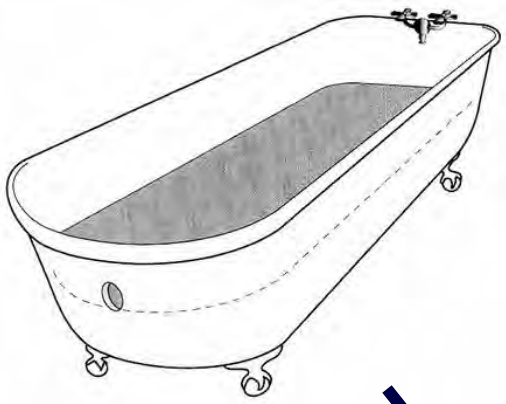
Courbe pression-volume ventriculaire droite



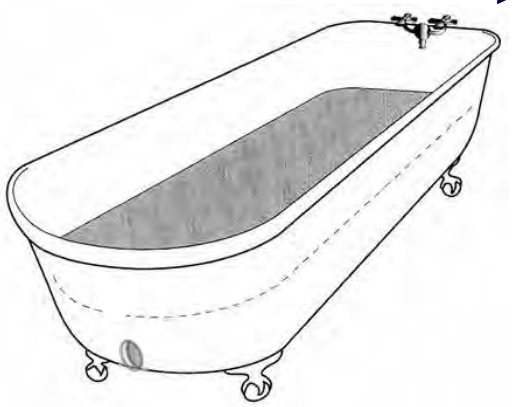
Courbe pression-volume ventriculaire gauche



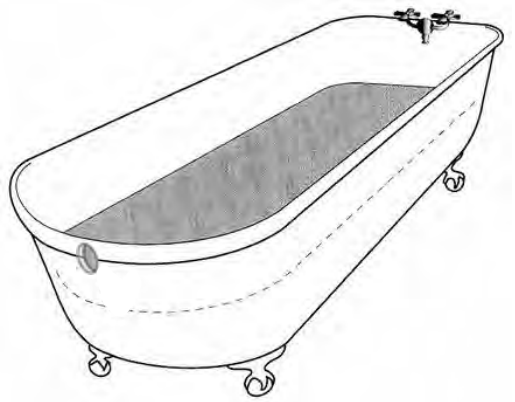
Pression de l’oreillette droite



↑ Fonction cardiaque:
↓Pod



↓ Fonction cardiaque:
↑ Pod



Adapated from: Jacobsohn et al Can J Anesth 1997 44:8 849-67

↓ du retour veineux si:

1-↓ Pvs: hypovolémie, vasodilatation

2-↑ Pod: dysfonction systolique ventriculaire gauche et droite

dysfonction diastolique ventriculaire gauche et droite

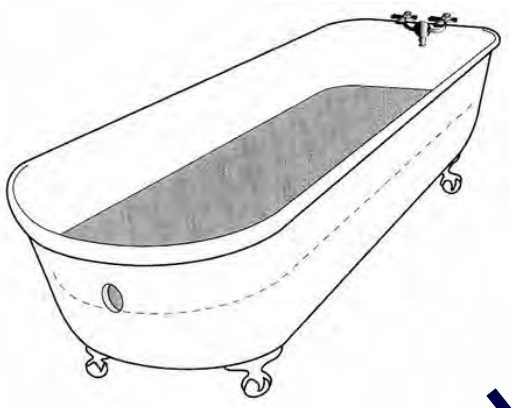
obstructions des valves et des chambres de chasse

embolies pulmonaires

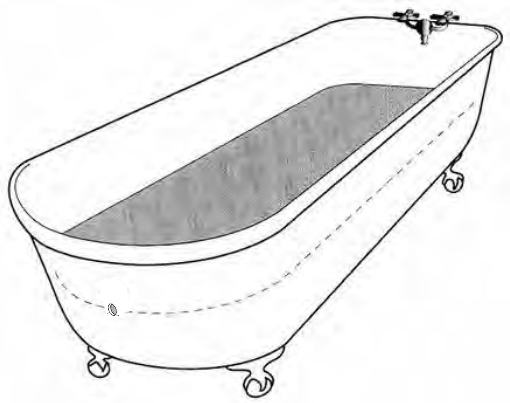
hypoxie et hypercapnie

3-↑ Rrv: obstruction intrinsèque ou extrinsèque (syndrome du compartiment) (péricardique, médiastinal, thoracique, abdominal)

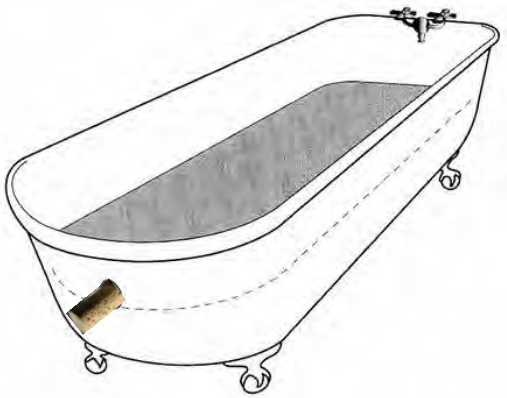
Résistance au RV



↓ taille de l'ouverture

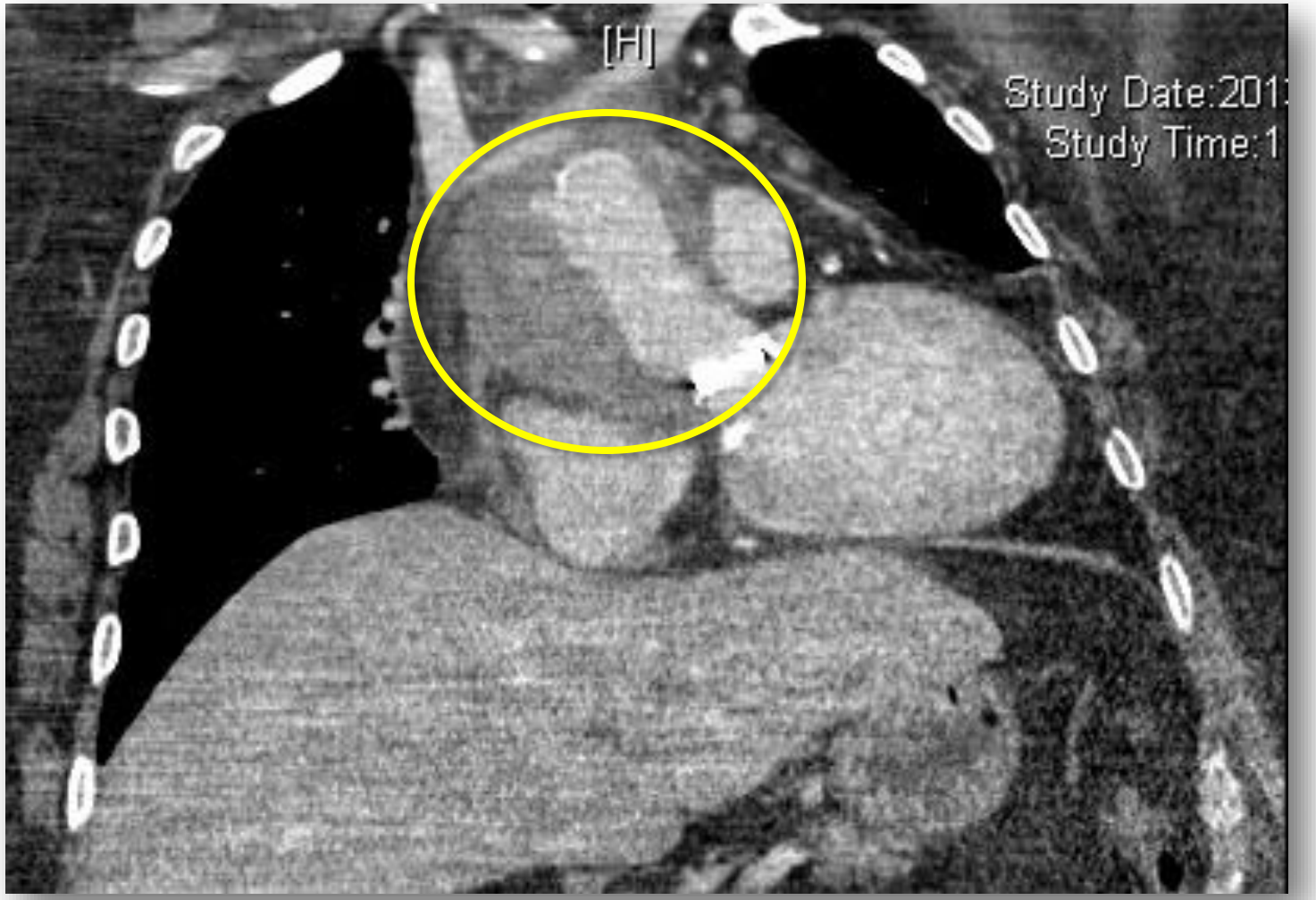


Obstruction de l'ouverture



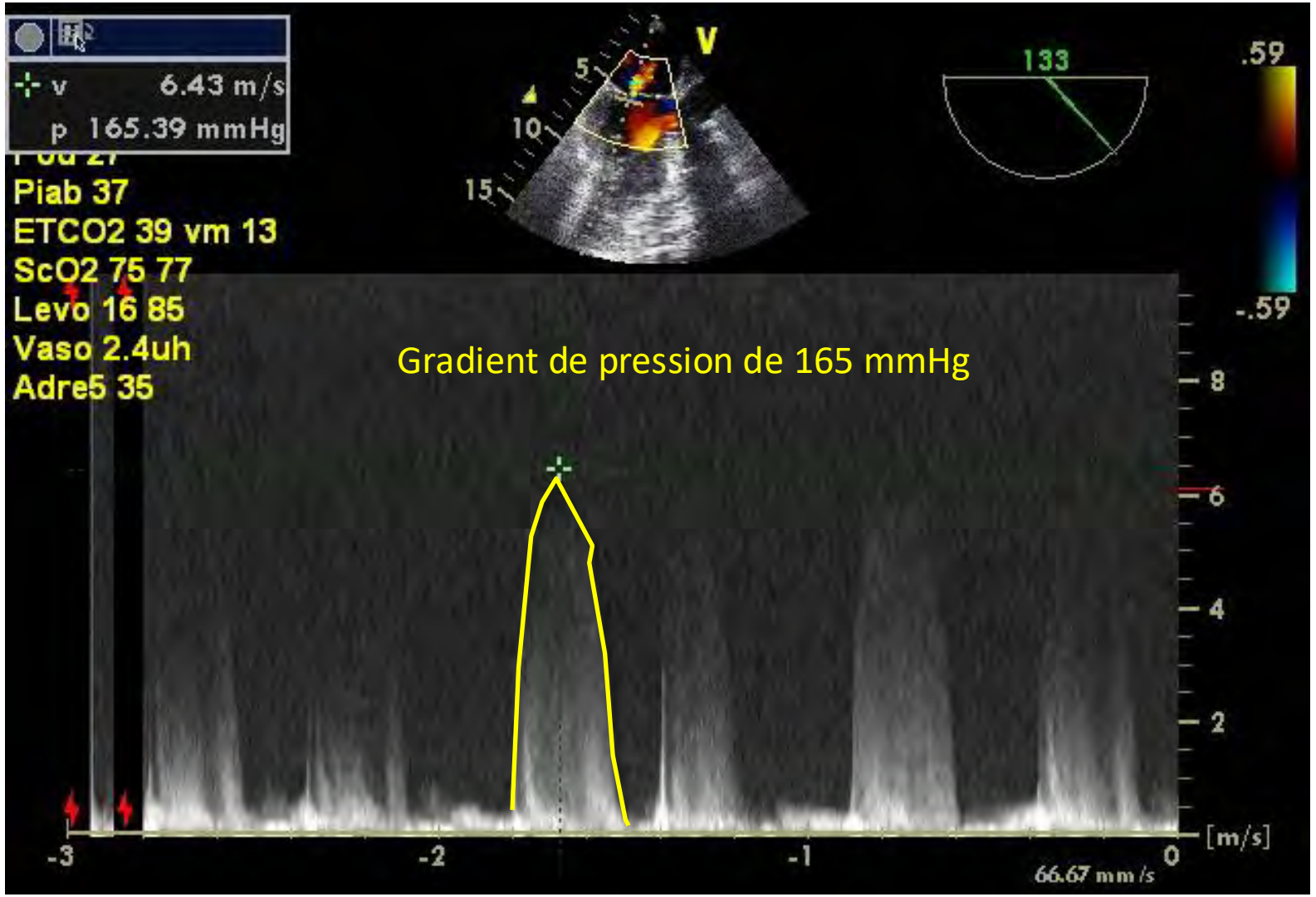
Adapté de: Jacobsohn et al Can J Anesth 1997 44:8 849-67

♂ 54 ans abcès péri-aortique

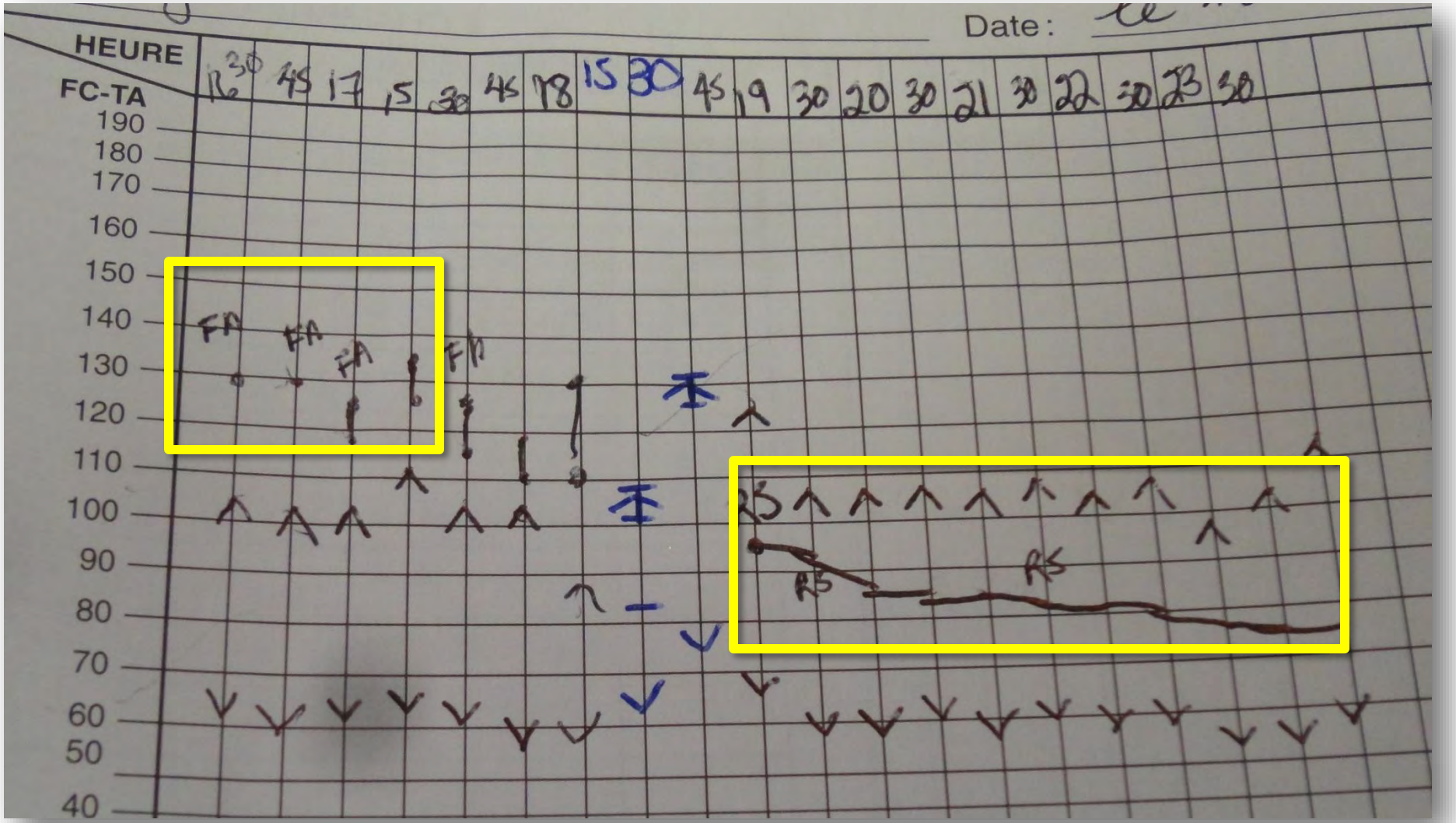


Instable aux soins intensifs

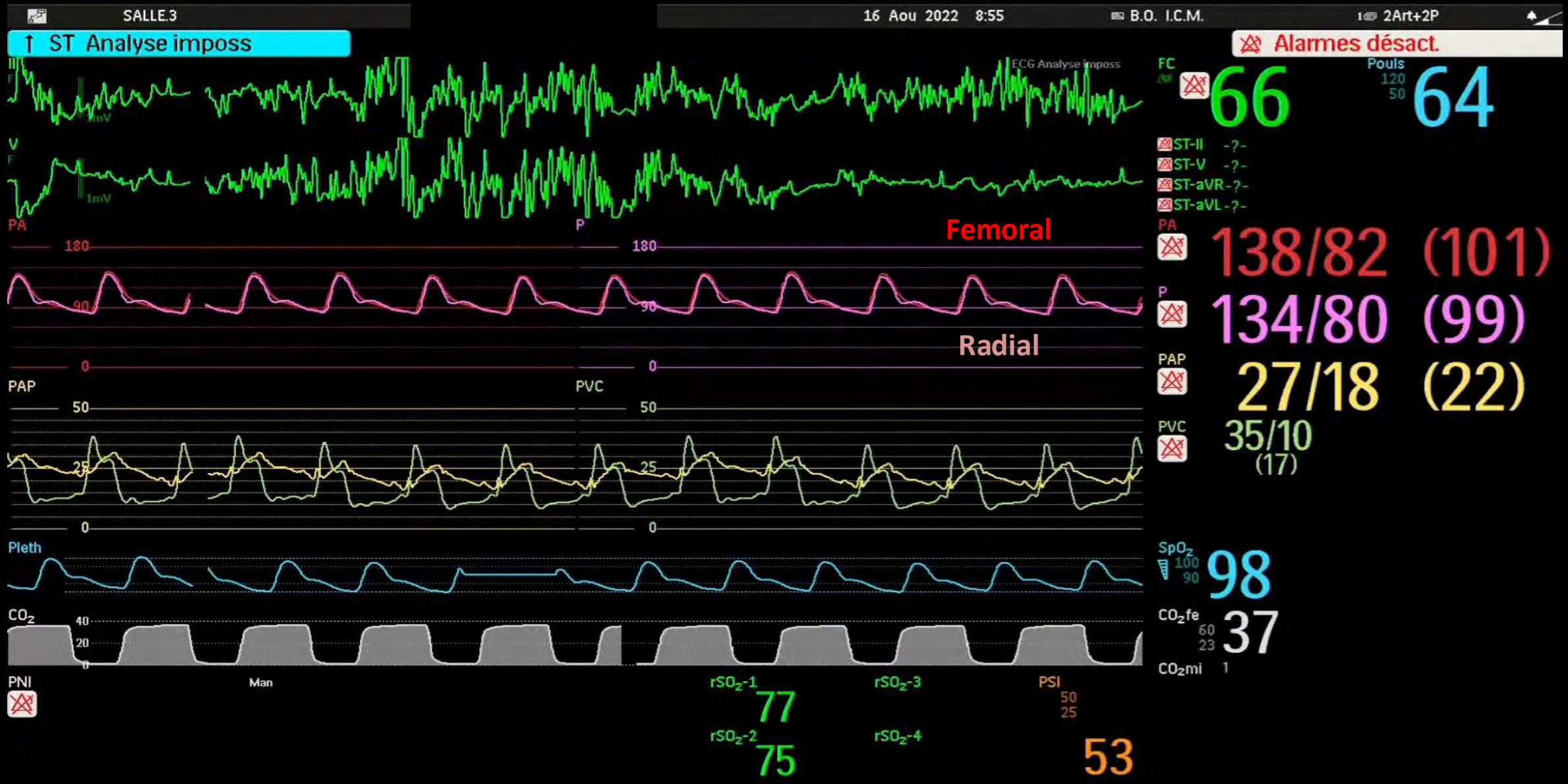
Pression artère radiale = 110/67 mmHg

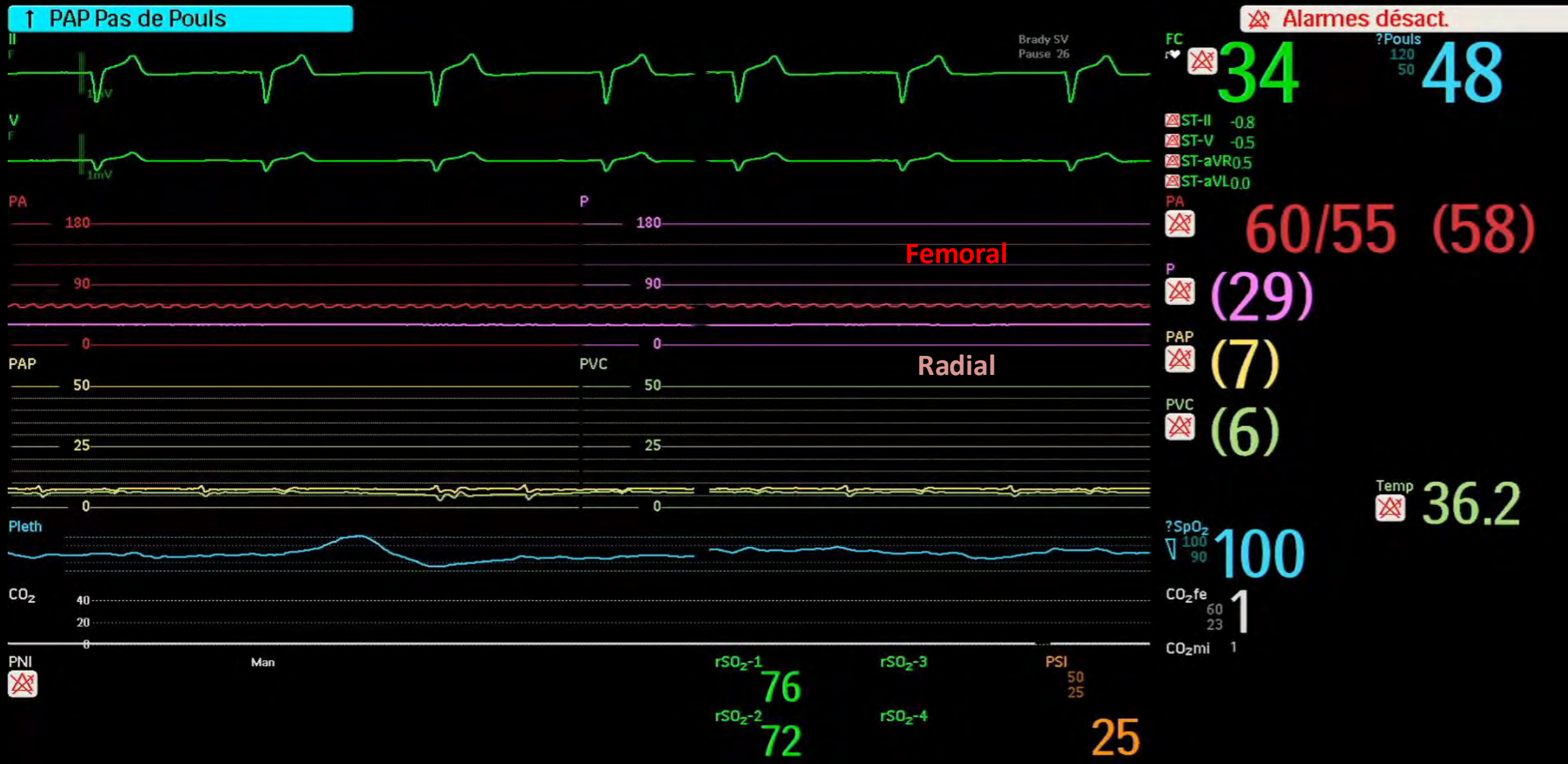



PAP SYST
PAP DIAST
PAP MOYENNE
D.C.
I.C.
RVS ☐ / IRVS ☐
Adré 5mg
SATURATION
CAPNOGRAPHIE


Date :
HEURE
FC-TA
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
FA
FA
FA
FA
RS
RS

52 ans pontage aorto-roronarien: 16 aout 2022



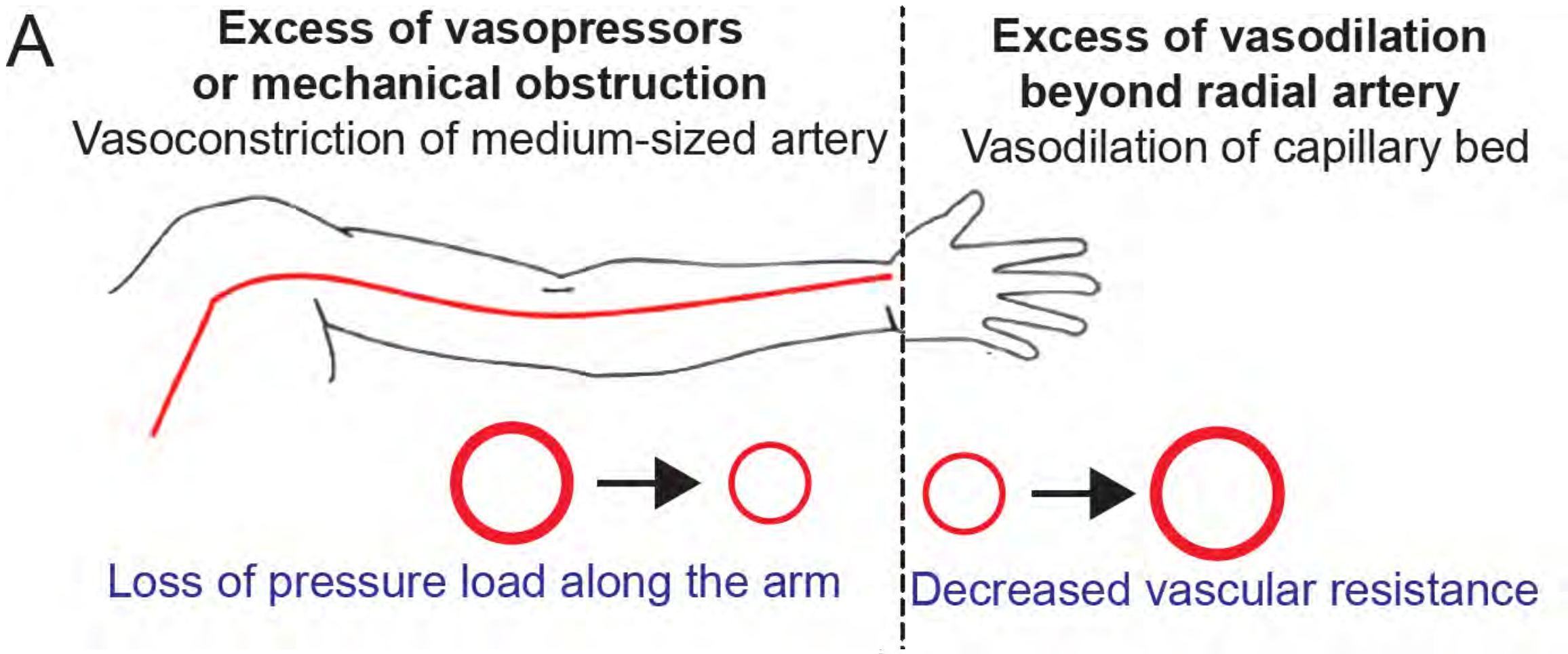

↑ PAP Pas de Pouls
Alarmes désact.
II
V
Brady SV
Pause 26
FC
34
?Pouls
120
50
48
ST-II -0.8
ST-V -0.5
ST-aVR 0.5
ST-aVL 0.0
PA
P
180
90
0
Femoral
PA
60/55 (58)
P
(29)
PAP
50
25
0
PVC
Radial
PAP
(7)
PVC
(6)
Temp
36.2
Pleth
?SpO2
100
90
100
CO2
40
20
0
CO2fe
60
23
1
CO2mi 1
PNI
Man
rSO2-1
76
rSO2-2
72
rSO2-3
rSO2-4
PSI
50
25
25


II
1mV
Brady SV
Pause 28
V
F
1mV
FC
34
Pouls
120
50
-?-
ST-II -0.6
ST-V -0.4
ST-aVR 0.4
ST-aVL 0.0
PA
180
90
0
Femoral
P
180
90
0
PA
87/57 (78)
P
(30)
PAP
50
25
0
Radial
PVC
50
25
0
PAP
(7)
PVC
(6)
Temp
36.3
Pleth
SpO2
100
90
-?-
CO2
40
20
0
CO2fe
60
23
1
CO2mi 1
PNI
Man
rSO2-1
75
rSO2-2
71
rSO2-3
rSO2-4
PSI
50
25
25

Can we trust radial artery pressure monitoring for cardiac surgery?

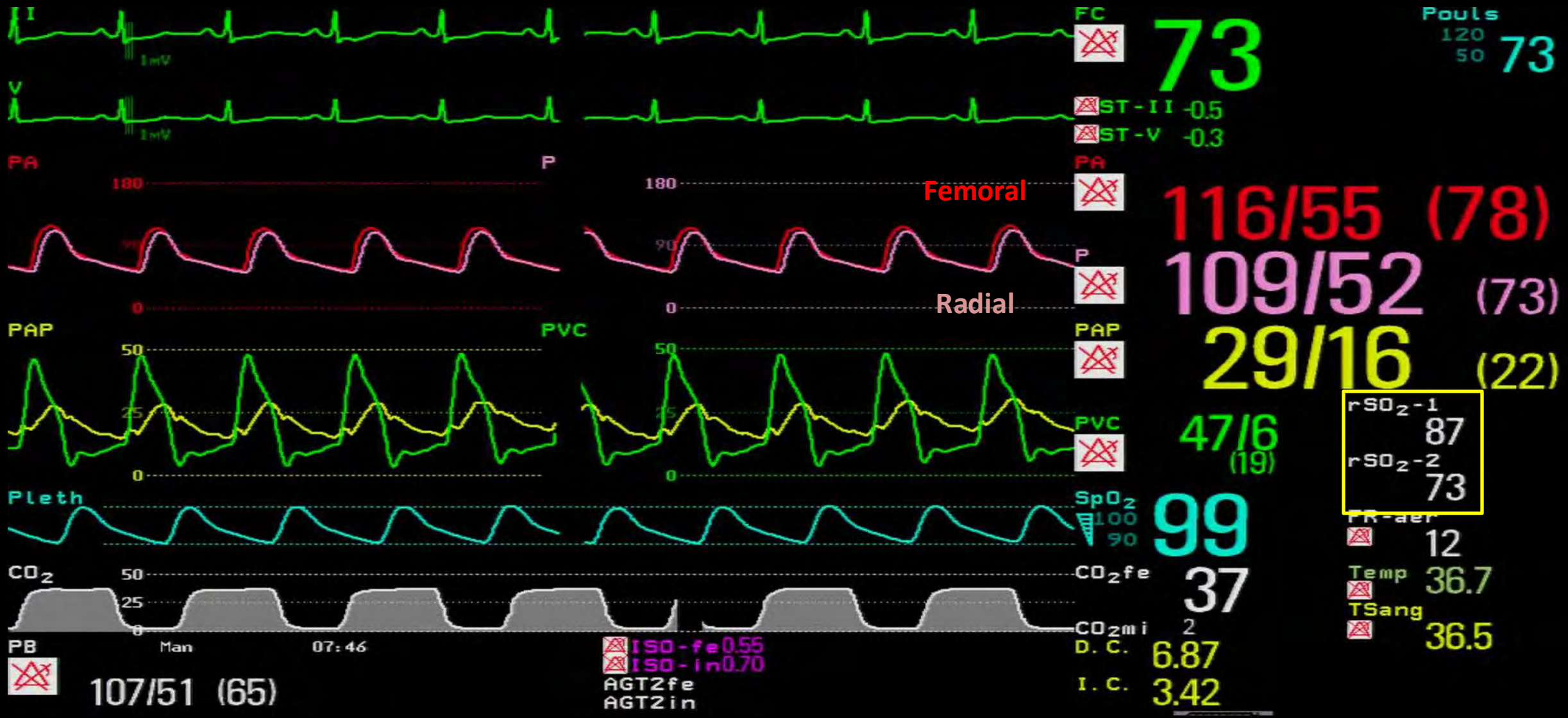
Matthias Jacquet-Lagrèze, MD, MSc · Adrian Costescu, MD, FRCPC · André Denault, MD, PhD, FRCPC, FASE, FCCS, ABIM

Can J Anaesth, 69(11), 1319-1326. https://doi.org/10.1007/s12630-022-02321-1

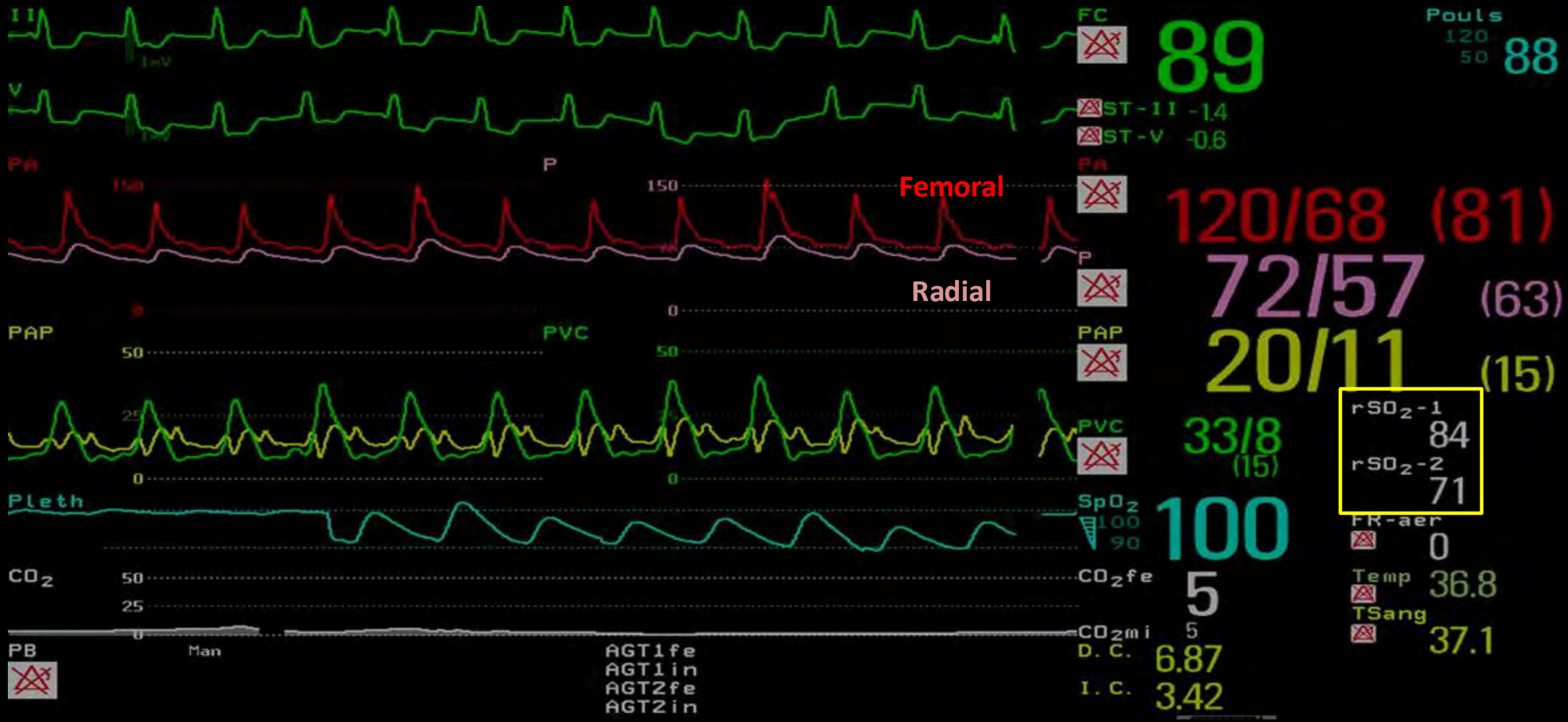


Journal Canadien Anesthésie 2022 (sous presse)

♂ 78 ans replacement valve aortique



Après la CEC


II
V
FC
89
Pouls
120
50
88
ST-II -1.4
ST-V -0.6
PA
P
150
Femoral
120/68 (81)
Radial
72/57 (63)
0
PAP
PVC
50
20/11 (15)
25
33/8 (15)
rSO2-1
84
rSO2-2
71
Pleth
SpO2
100
90
100
fR-aer
0
CO2
50
25
0
CO2fe
5
Temp
36.8
TSang
37.1
CO2mi
5
PB
Man
AGT1fe
AGT1in
AGT2fe
AGT2in
D.C.
6.87
I.C.
3.42

♂ 61 ans pontage et RVM

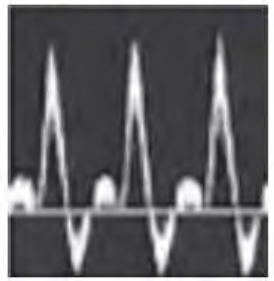
9:08

11:36

B

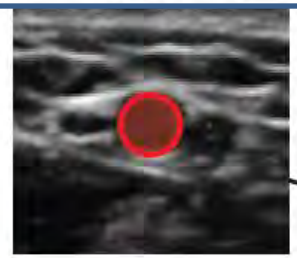
Subclavian stenosis

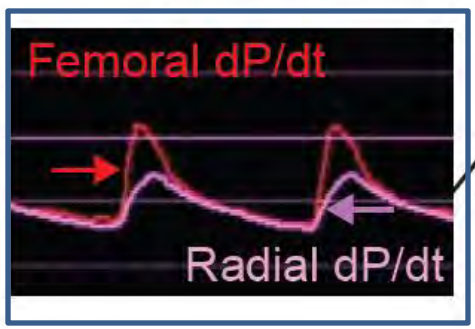
Normal triphasic pattern

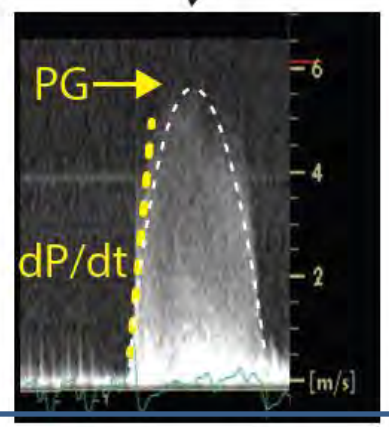


NIBP > Radial AP

Radial artery diameter
< 1.8 mm

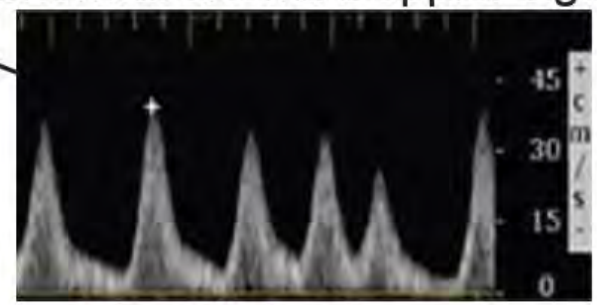




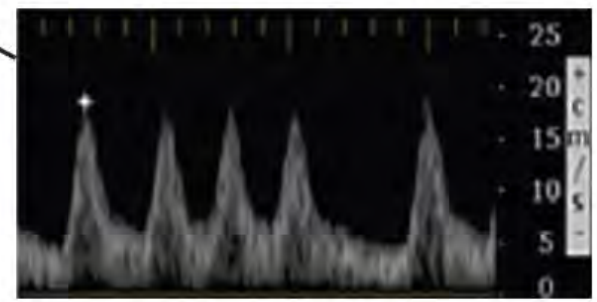


Radial AP < MR pressure gradient (PG)
Radial AP dP/dt < MR dP/dt

Abnormal arterial Doppler signal



Brachial: 39.6 cm/s



Radial: 18.8 cm/s

EACTAIC
FELLOWSHIP SEMINAR
SERIES 2, EPISODE 1

Perioperative Hemodynamic Monitoring

Can you trust a radial artery pressure?

André Denault MD PhD FRCPC,CSPQ, ABIM-CCM, FASE, FSCC
Professor of Anesthesia Whole body ultrasound program director in critical care and anesthesia
Department of anesthesiology and critical care division
Montreal Heart Institute, Canada

Mathias Jacquet-Lagreze MD PhD
Department of anesthesiology and critical care
Lyon, France

Université de Montréal

ICM

HCL HOSPICES CIVILS DE LYON

Inserm

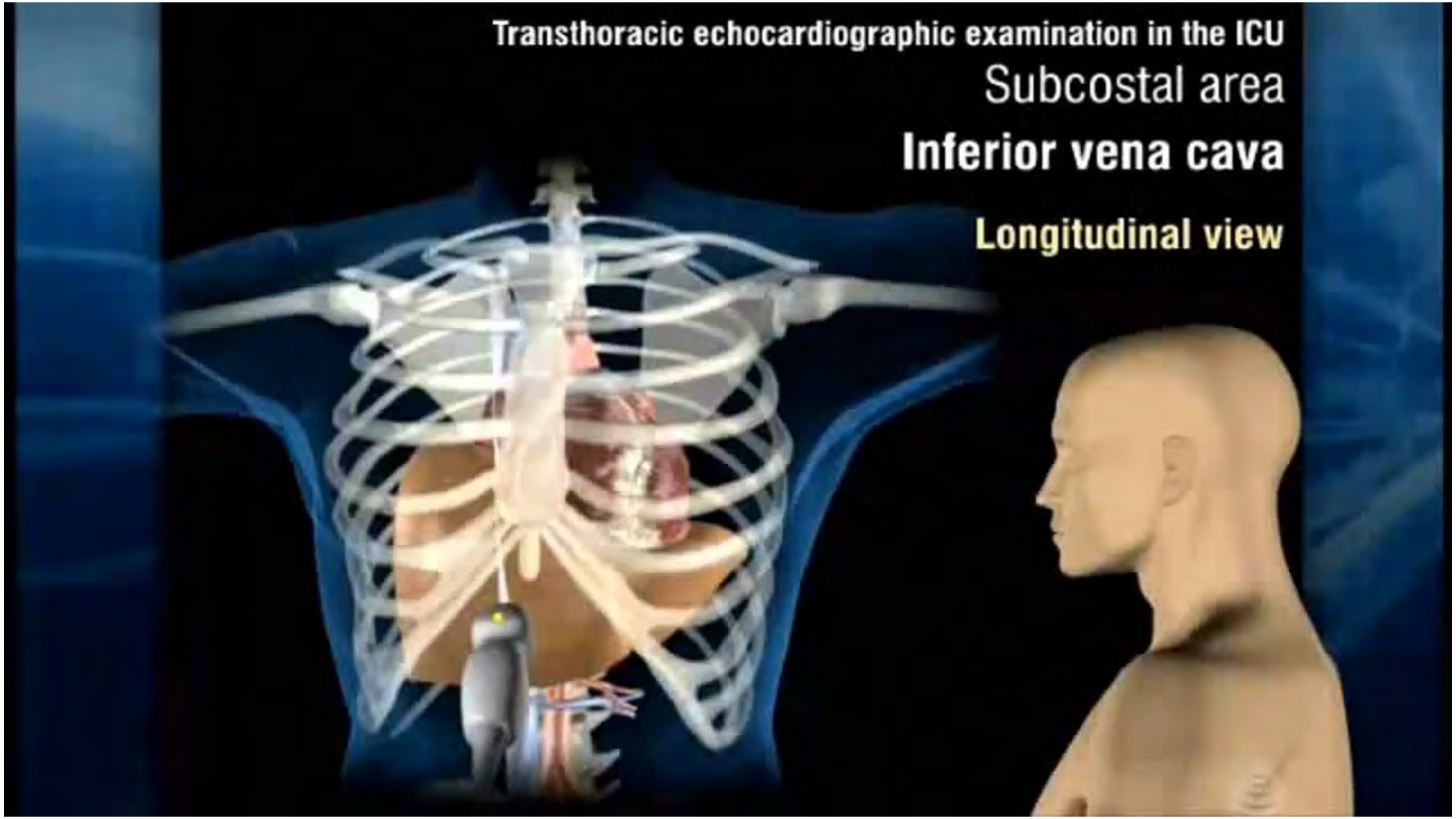
Leuven University
>> Leuven, Belgium

https://vimeo.com/798388140 (25 minutes)

Évaluation de la volémie

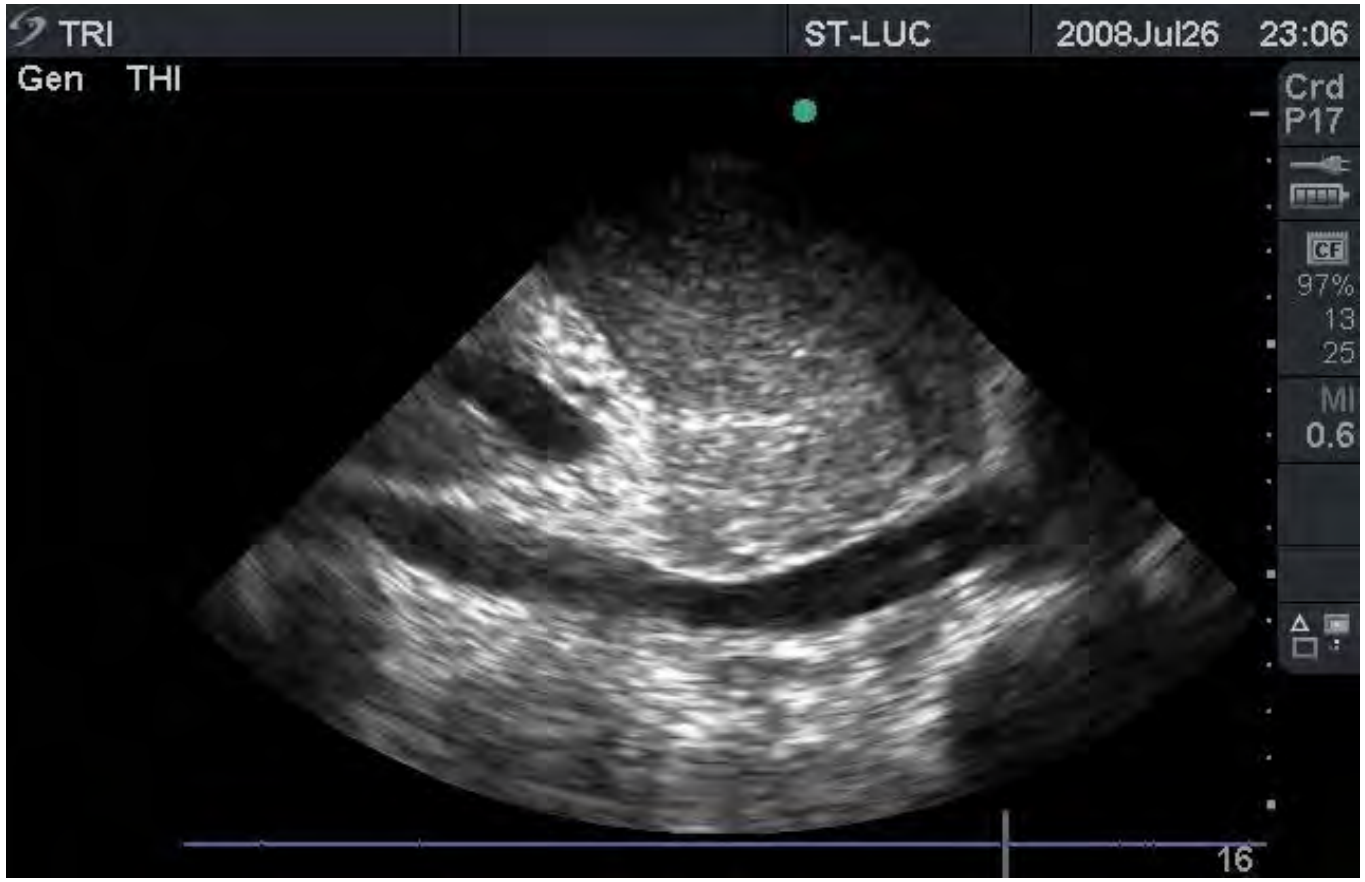
- Dépends de la fonction cardiaque systolique et diastolique
- En ventilation spontanée ou assistée?
- Réponse au volume = plus important
- Réponse dépends: Pvs, Pra et Rvr
- Par ordre de fiabilité: réponse au volume
  - Wedge < TVC < aires échographiques < variation respiratoires artérielles < variations respiratoires veineuses < élévation des jambes

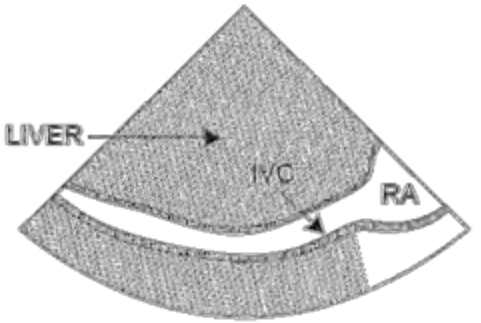
Vue sous-xyphoïdienne 90°

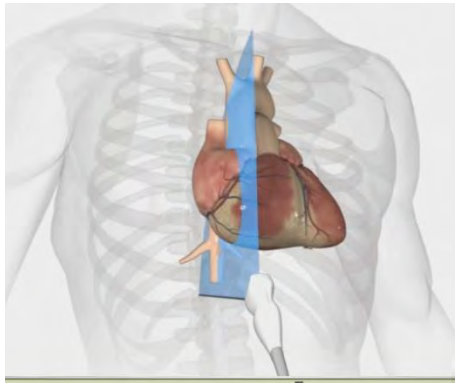


Courtoisie de CAE Healthcare

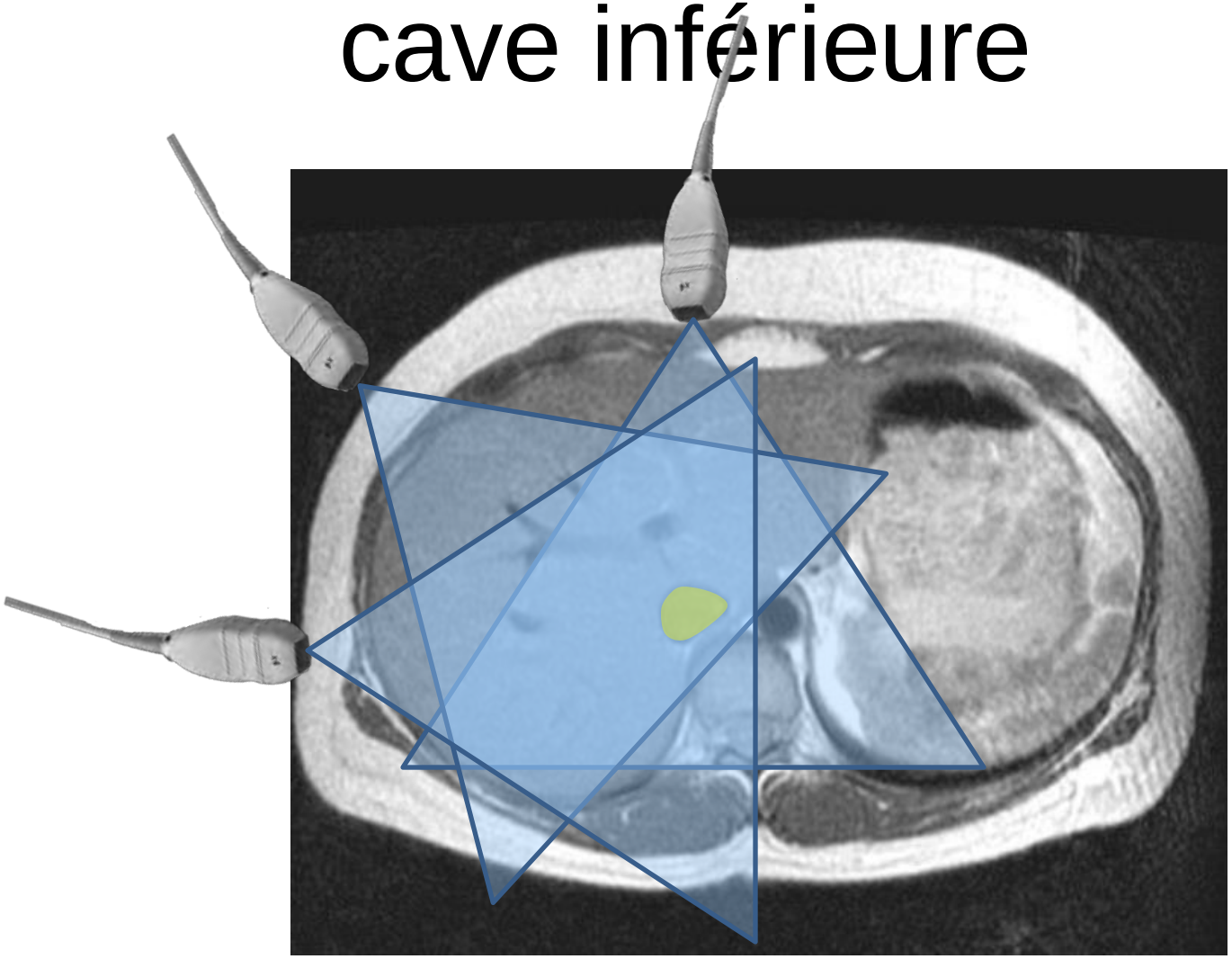
Réponse au volume +

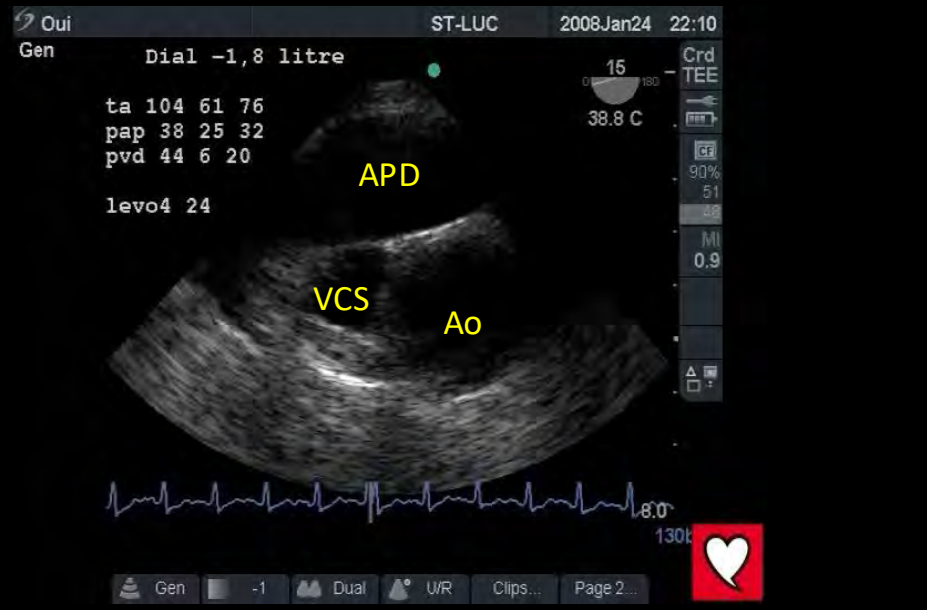


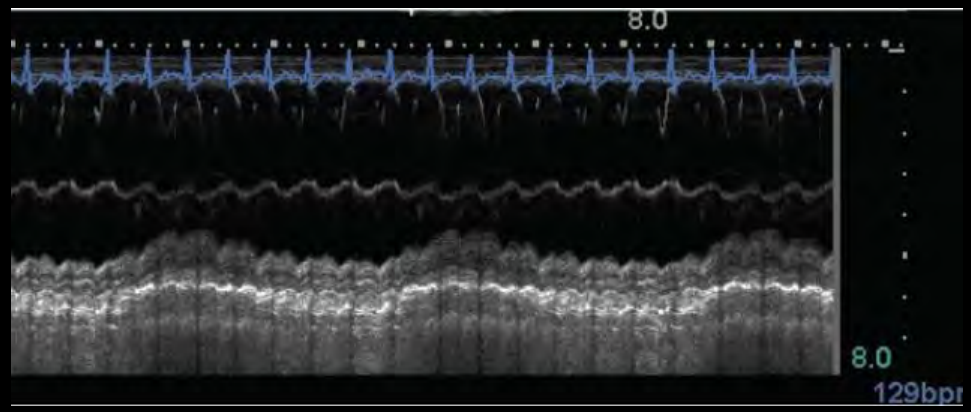


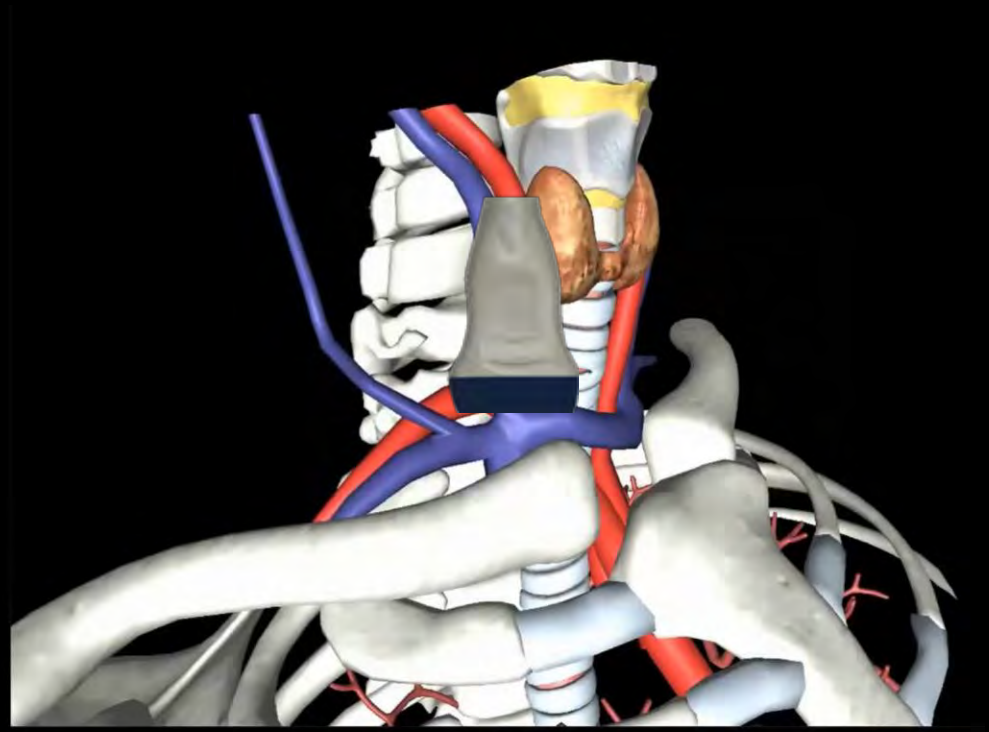


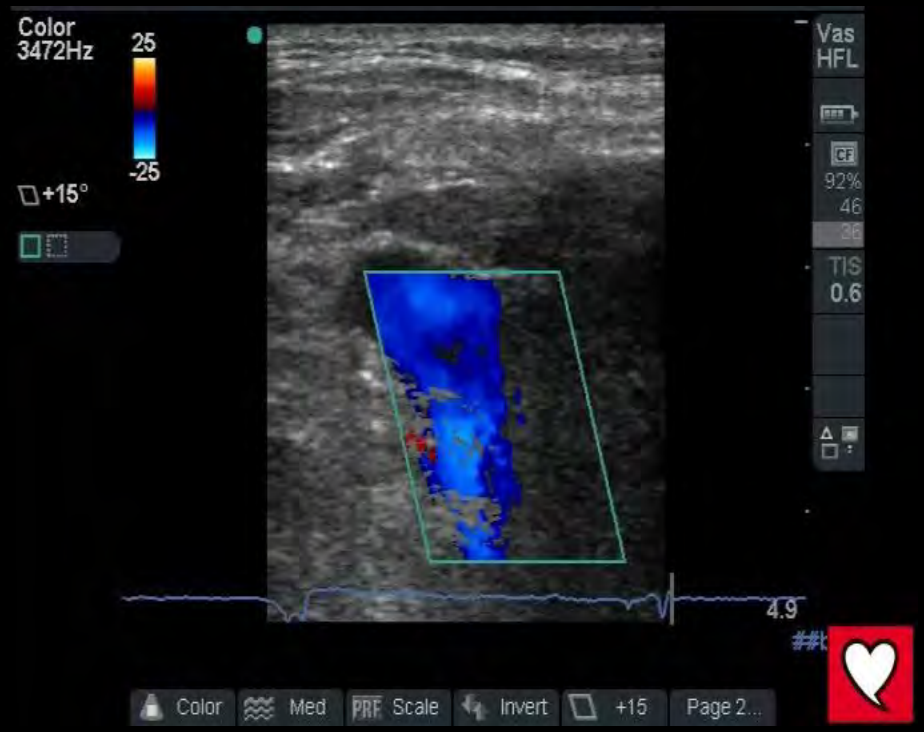
Vues alternatives de la veine cave inférieure



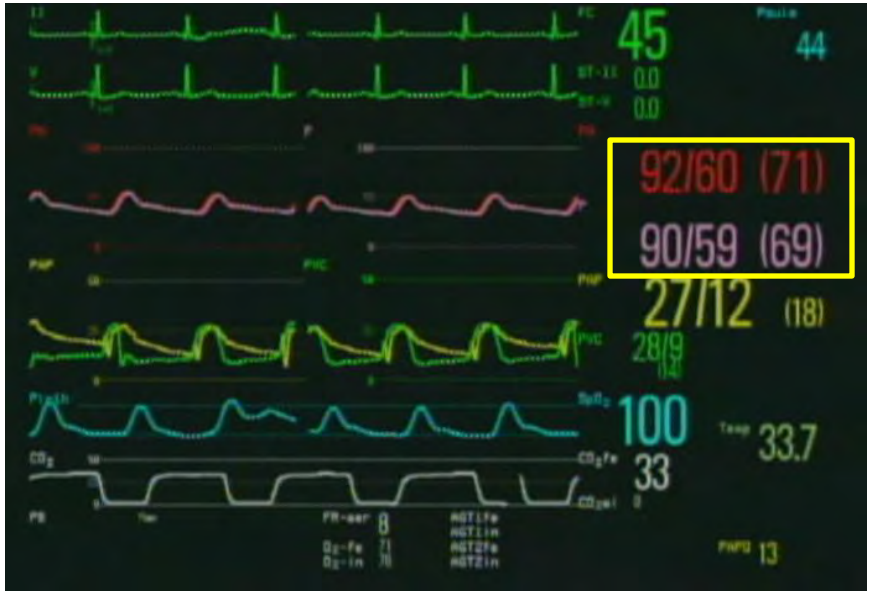

Oui
ST-LUC
2008Jan24 22:10
Gen
Dial -1,8 litre
ta 104 61 76
pap 38 25 32
pvd 44 6 20
levo4 24
APD
VCS
Ao
15
38.8 C
Crd
TEE
90%
51
MI
0,9
8.0
Gen
-1
Dual
U/R
Clips...
Page 2...


8.0
8.0
129bpr

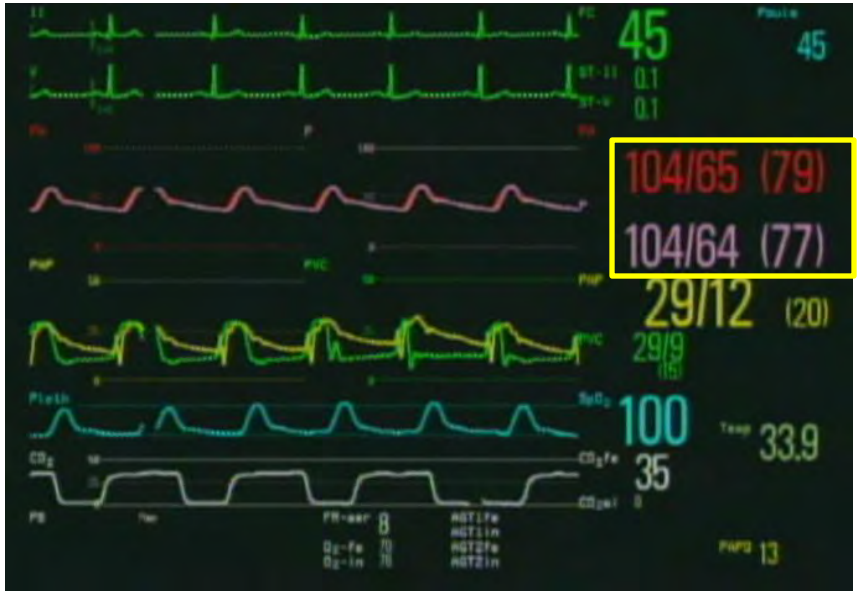


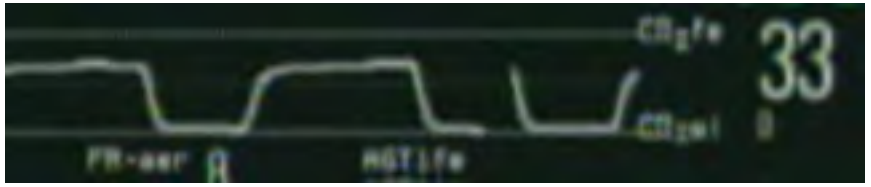

Color
3472Hz
25
-25
+15°
Vas
HFL
CF
92%
46
TIS
0.6
4.9
Color
Med
PRF Scale
Invert
+15
Page 2...

Avant

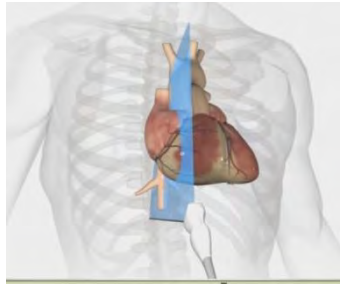


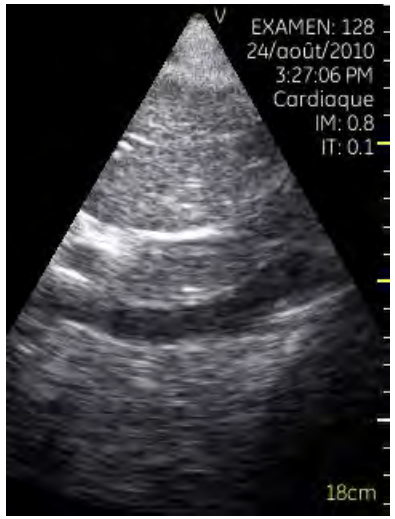
Après





Teboul JL, et al. Minerva Anestesiol (2013), 23370121





État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Pertes sanguines

Choc hypovolémique

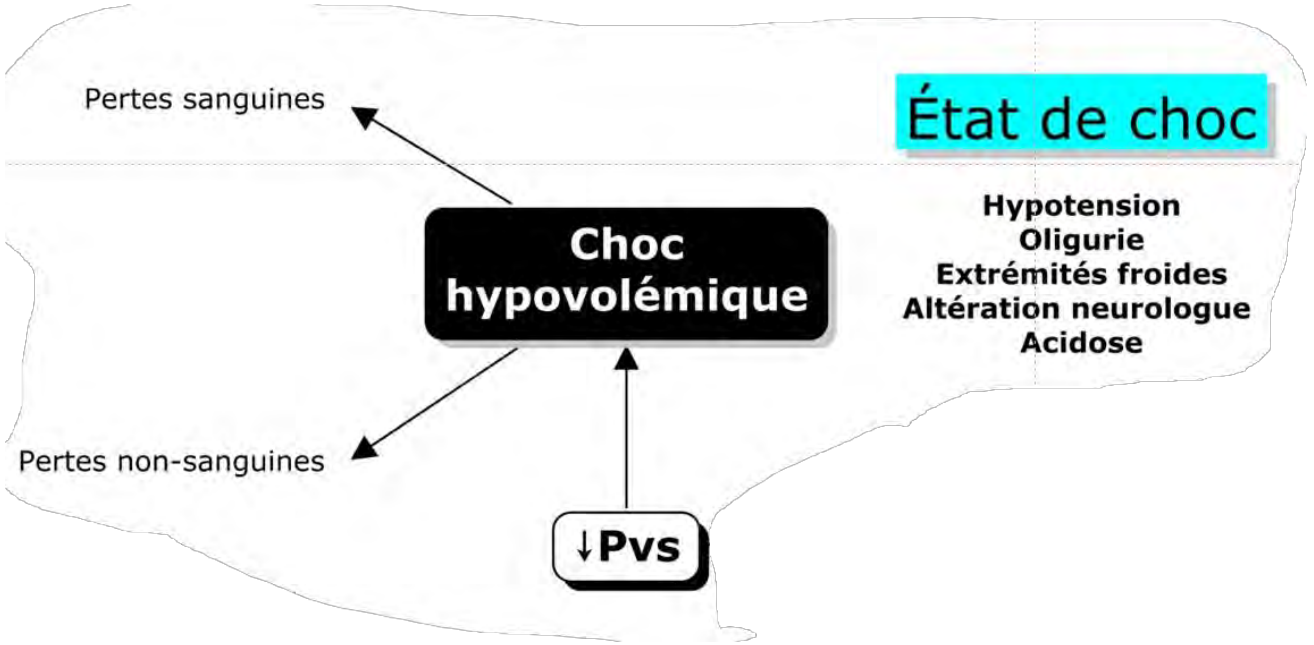
Pertes non-sanguines

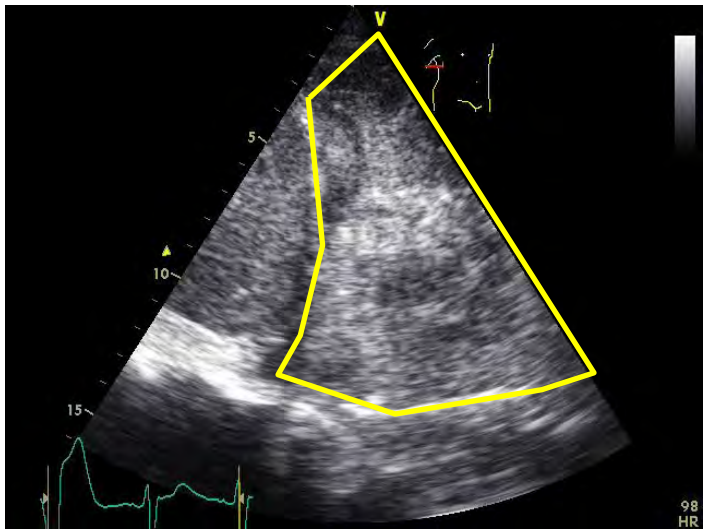
↓Pvs

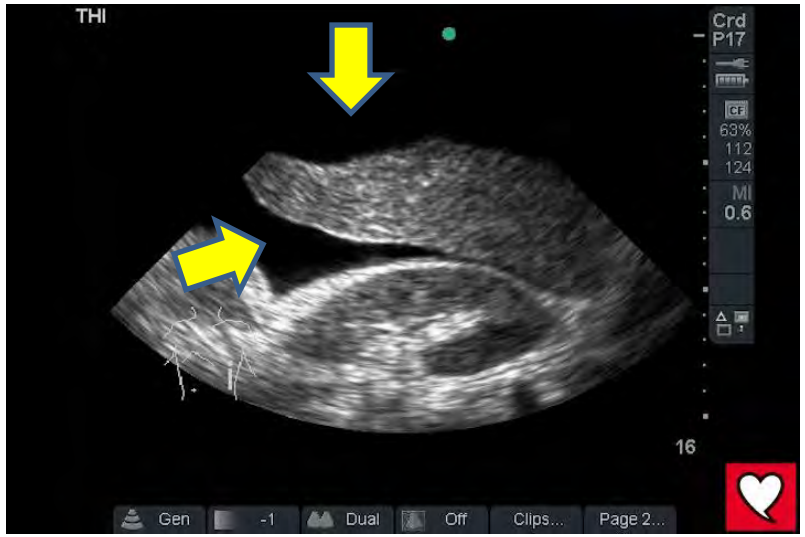
Choc distributif

Septique

Non-septique


Pertes sanguines
État de choc
Choc hypovolémique
Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose
Pertes non-sanguines
↓Pvs


V
5
10
15
98
HR

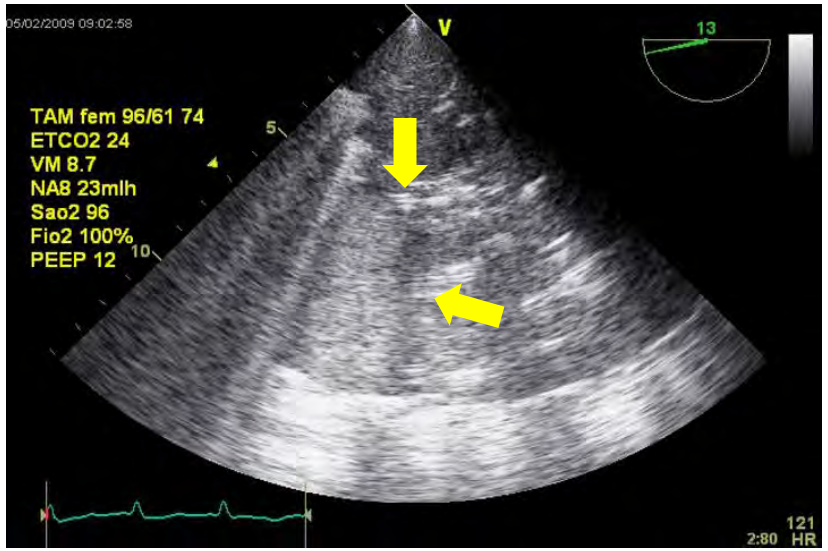

THI
Crd
P17
63%
112
124
MI
0.6
16
Gen
-1
Dual
Off
Clips...
Page 2...

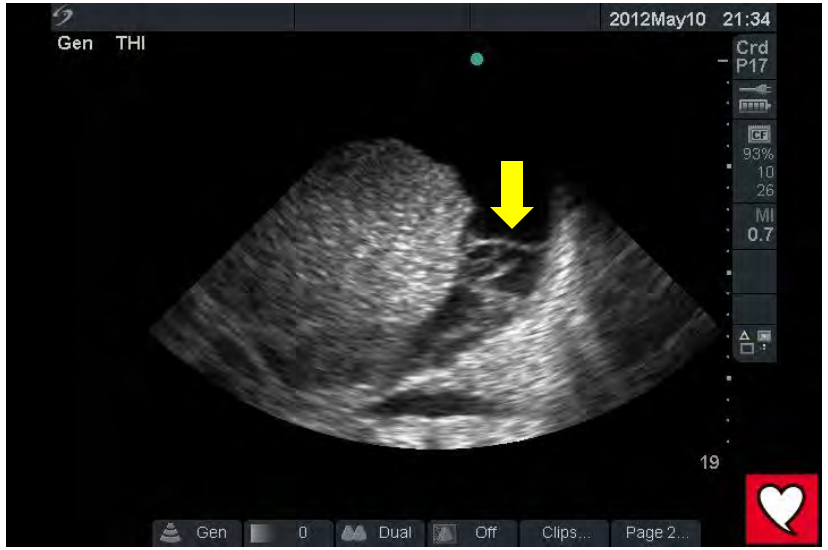
État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

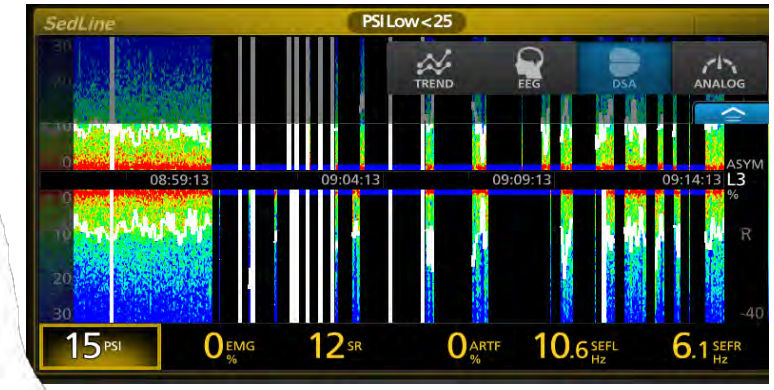
Choc distributif

Septique





↓Pvs → Choc distributif → Non-septique

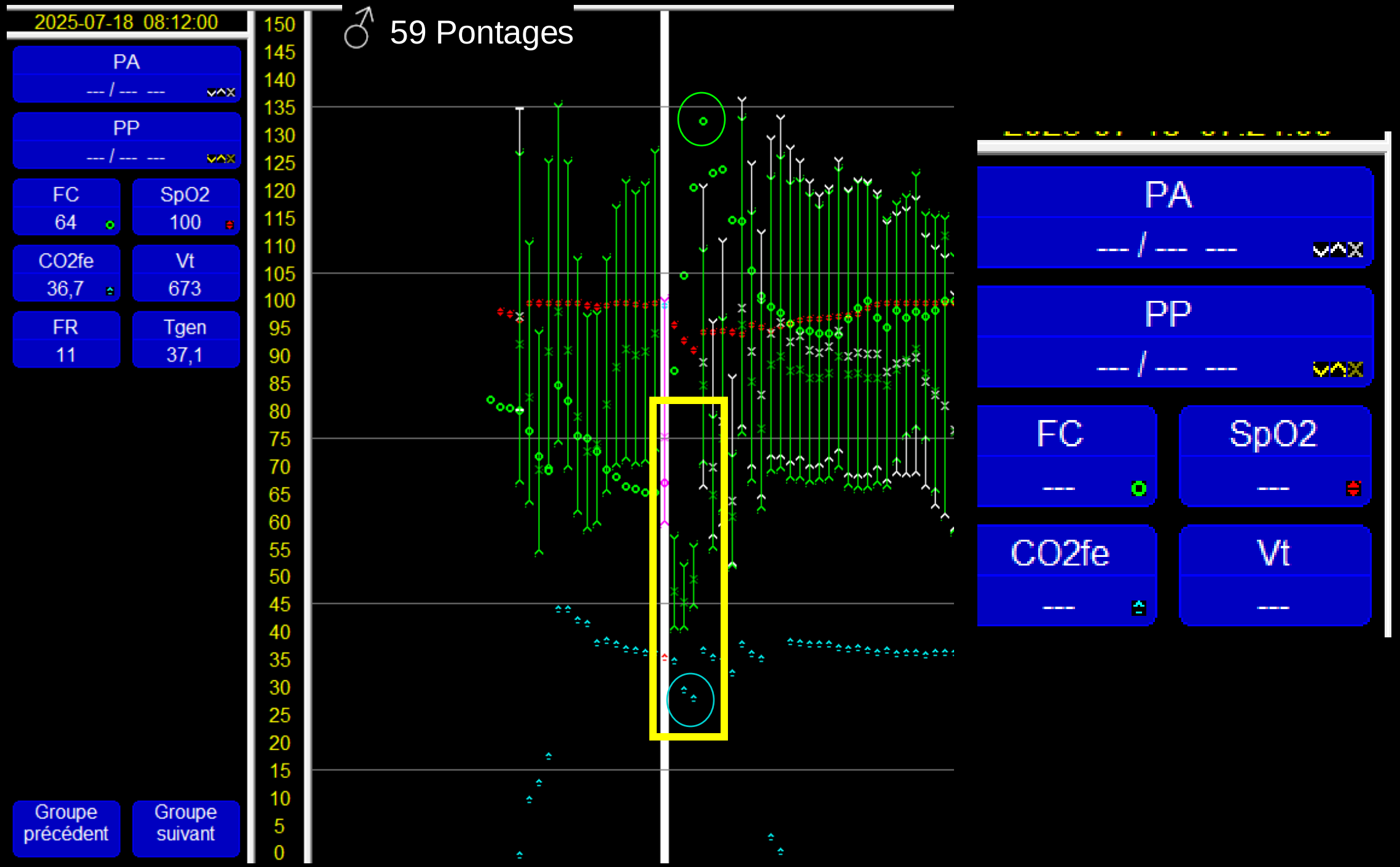


STAT

S(4): Sepsis
- **Shock: prolonged of any cause (CPB, hemorrhagic, cardiac)***
- **Spurious (pseudo radial hypotension)**
- **Sedatives (in excess)**

Toxic: CO, nitrogen, metformin, cyanide, mitochondrial disease
Addison & Anaphylactic
Thyroid: ↓

***Landry NEJM 2001**

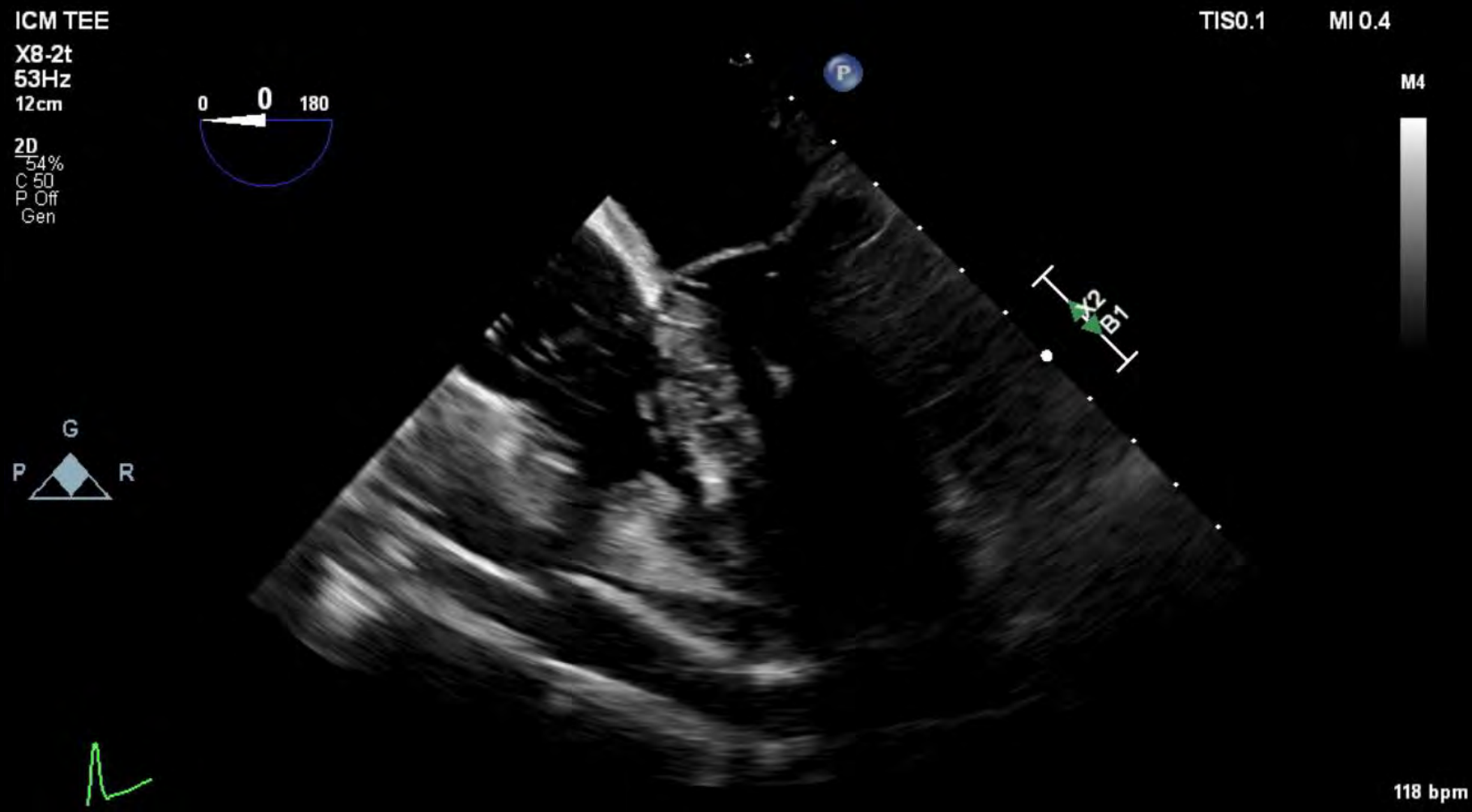

2025-07-18 08:12:00
♂ 59 Pontages
PA
--- / --- ---
PP
--- / --- ---
FC
64
SpO2
100
CO2fe
36,7
Vt
673
FR
11
Tgen
37,1
Groupe précédent
Groupe suivant
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
PA
--- / --- ---
PP
--- / --- ---
FC

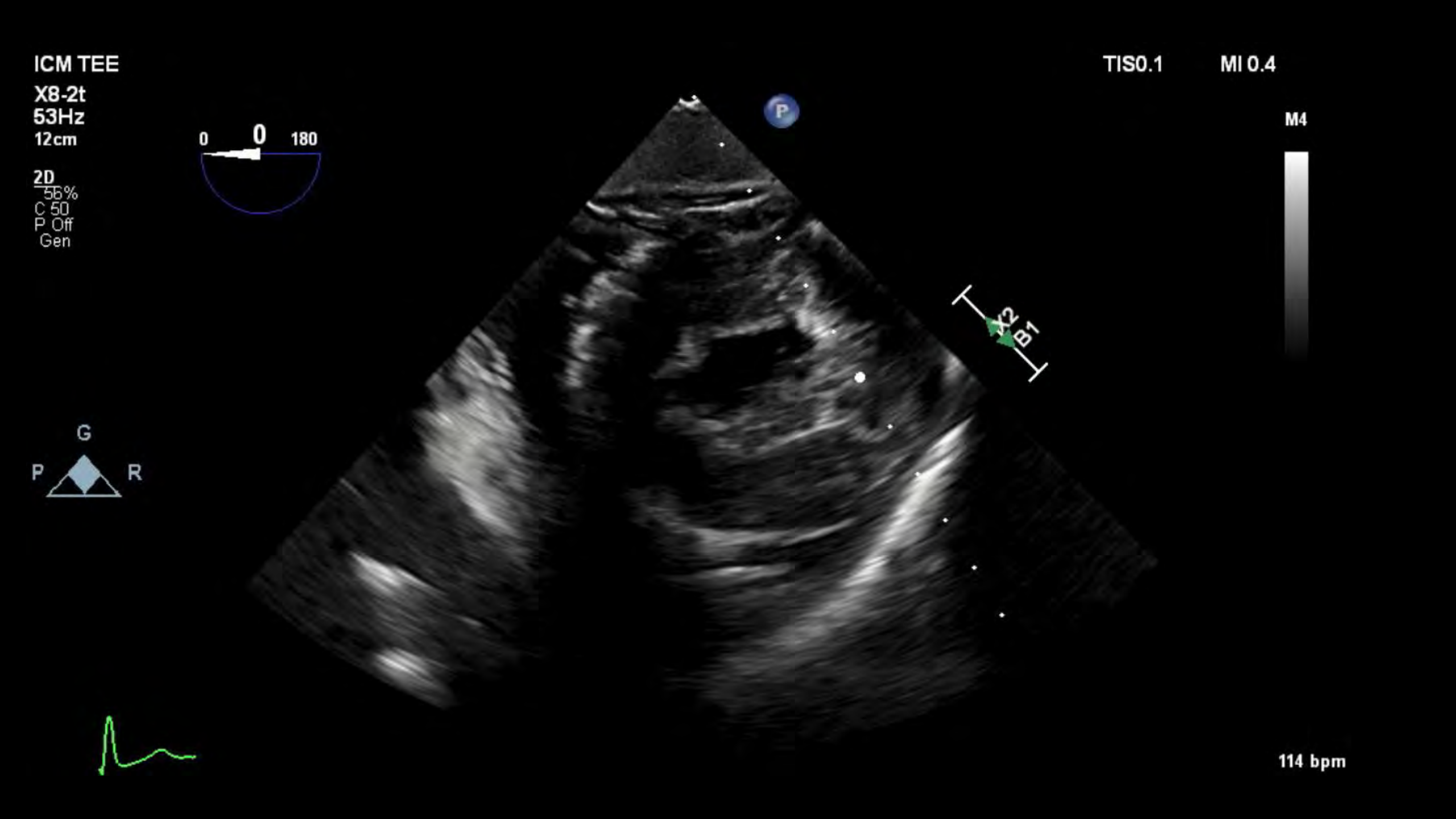
SpO2

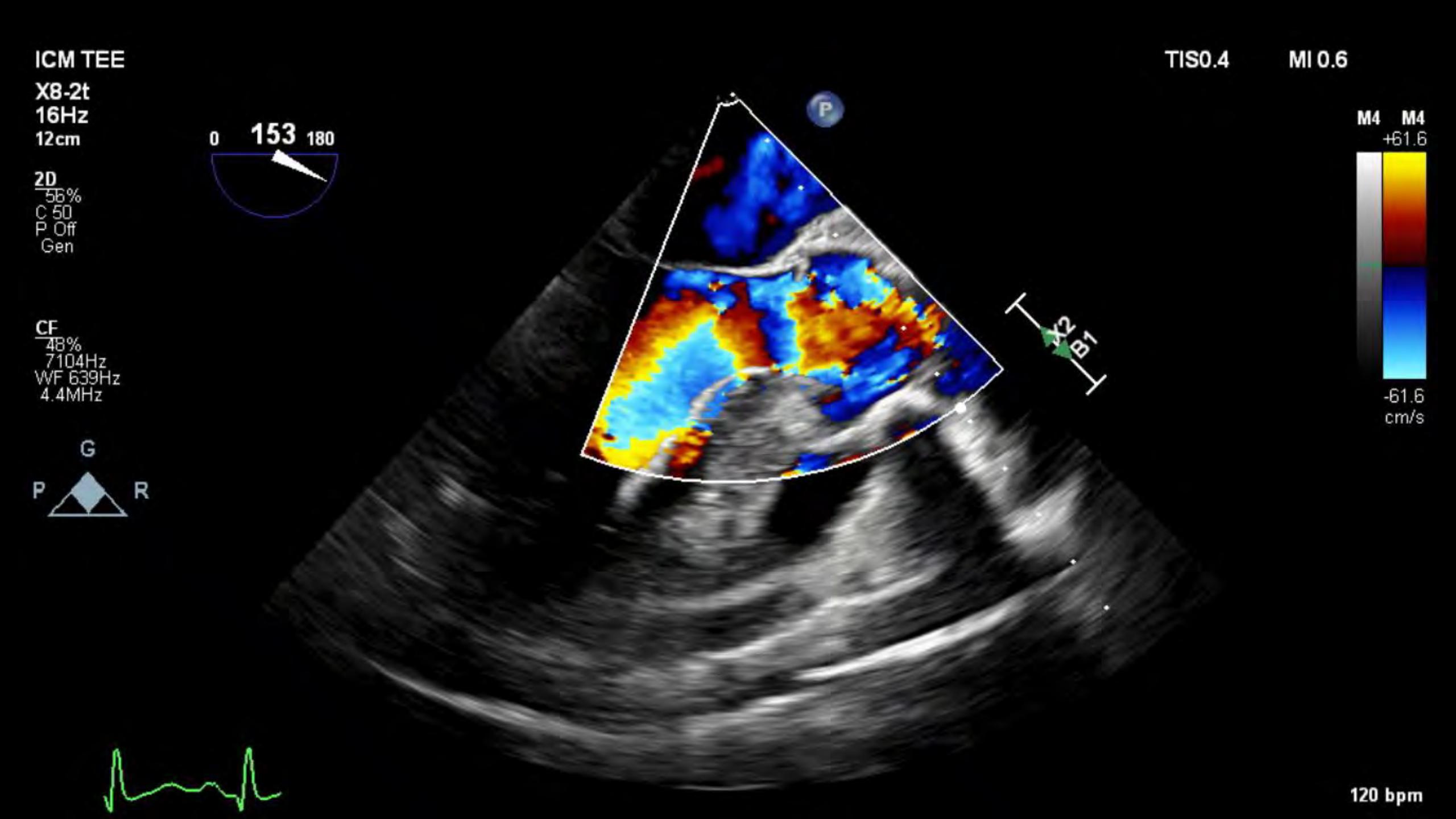
CO2fe

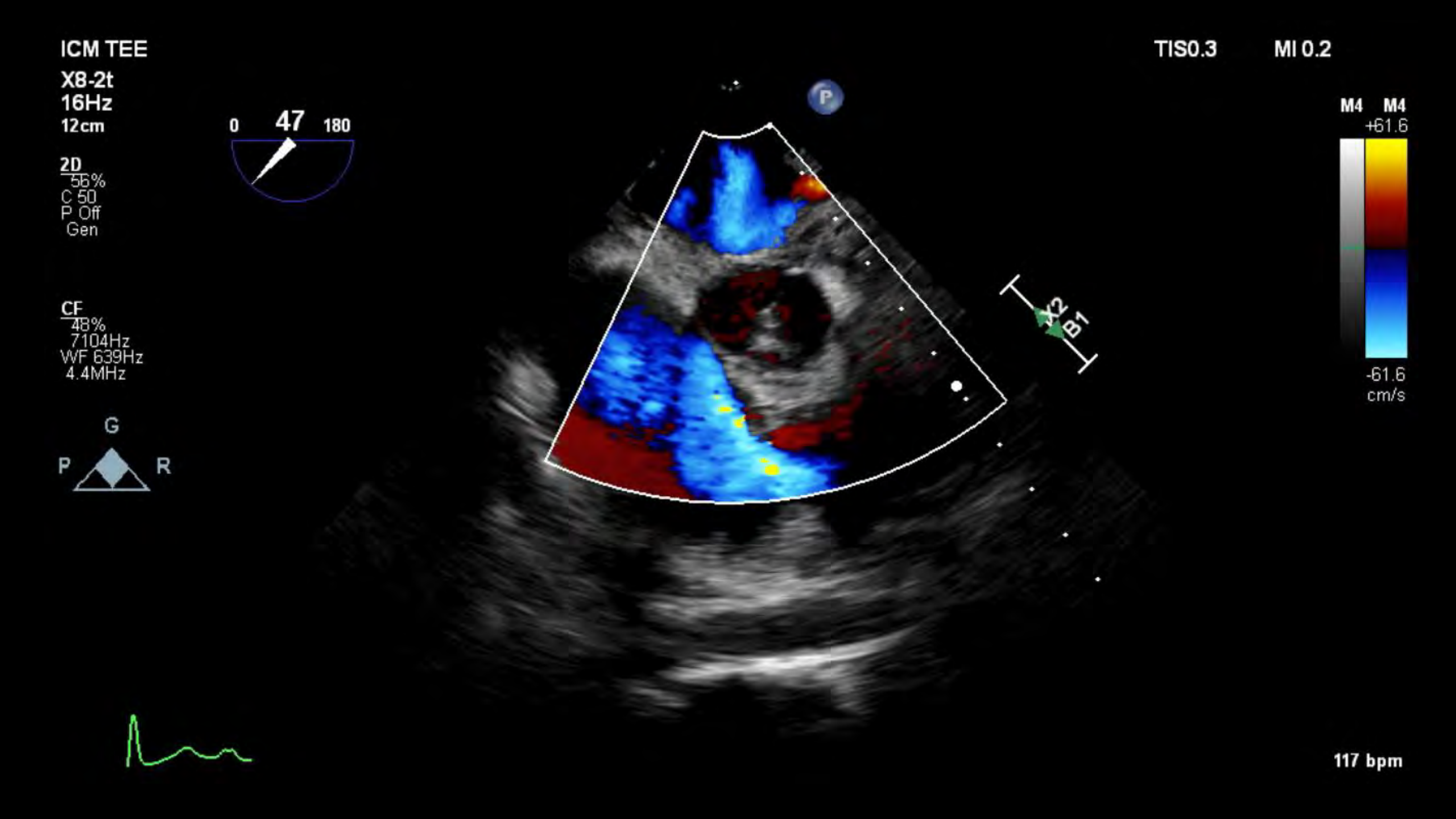
Vt

08:25	Commentaire	Hypotension subite ad 50 TAs, réfractaire à phenylephrine 200ug + perfusion. Suspicion rapide d'anaphylaxie+administration d'adrénaline avec bonne réponse HD. Stabilisation avec 1L PL + Solumedrol 125mg + famo 20mg+ benadryl 50mg. (ancef vs roc vs heparin		
08:30	Commentaire	bronchospasme 2aire anaphylaxie probable (cf note) aucune désaturation, augmentation pression ventilation ad 34 (base 24), amélioration avec ventolin 8inh via TET, stable ave 0,1 ug/kg/min d'adré. Décision de poursuivre avec chx. Tryptase dosé, c all. ext		
08:30	Commentaire	Sequence d'evenement = hypotension subite avec tachycardie et evidence echographique de choc anaphylactique. Phenyl 200 mcg (aucun effet) levo 6 mcg + 6 mcg IV aucun effet. Adrénaline 10 + 40 + 50 mcg		
08:30	Commentaire	retour a des parametres HD stable. Suspicion forte pour la cefazolin ou rocu ... pas de perf cefa mais 1 g Vanco pour couverture per-op. et a poursuivre aux SIC. pas d'autre dose de rocu mais utilisation du Cis-Atracurium pour la suite.		
08:32	Épinéphrine	0,1 µg/kg/min	IV-Perfusion	5 mg/250 ml
08:32	Phényléphrine(0.1mg/ml)	0 ml/h	IV-Perfusion	10 mg/100 ml




ICM TEE
X8-2t
53Hz
12cm
2D
56%
C 50
P Off
Gen
0
0
180
TIS0.1
MI 0.4
M4
P
X2
B1
G
P
R
114 bpm


ICM TEE
X8-2t
16Hz
12cm
2D
56%
C 50
P Off
Gen
CF
48%
7104Hz
WF 639Hz
4.4MHz
G
P
R
0
153
180
TIS0.4
MI 0.6
M4
M4
+61.6
-61.6
cm/s
X2
B1
120 bpm


ICM TEE
X8-2t
16Hz
12cm
2D
56%
C 50
P Off
Gen
CF
48%
7104Hz
WF 639Hz
4.4MHz
G
P
R
0
47
180
TIS0.3
MI 0.2
M4 M4
+61.6
-61.6
cm/s
X2
B1
117 bpm

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Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Stéphanie Jarry
PhD(c)

Étienne Couture
MD PhD(c)

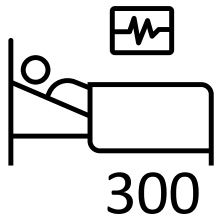
Original Research

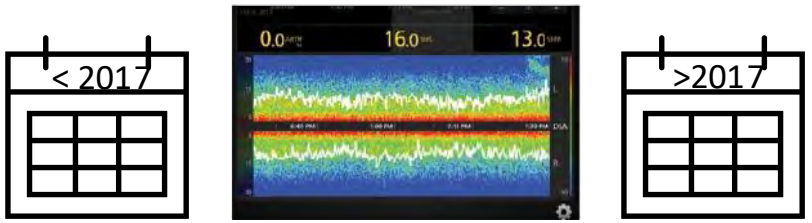
Impact of Processed Electroencephalography in Cardiac Surgery: A Retrospective Analysis

Stéphanie Jarry, MSc[*], Isabelle Halley, BPharm[*], Alexander Calderone, MD[*], Mona Momeni, MD[†], Alain Deschamps, MD, PhD[*], Philippe Richebé, MD, PhD[§], William Beaubien-Souligny, MD, PhD[‖], André Denault, MD, PhD[*,‡,ǁ], Etienne J. Couture, MD[¶]

S. Jarry, et al. J. Cardiothorac. Vasc. Anesth. (2022) doi: 10.1053/j.jvca.2022.03.030

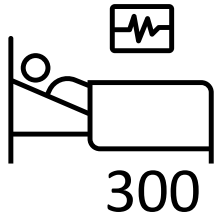
Impact of Processed Electroencephalography in Cardiac Surgery: A Retrospective Analysis

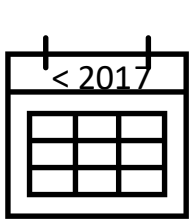


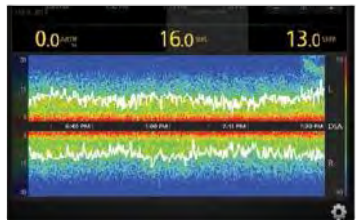


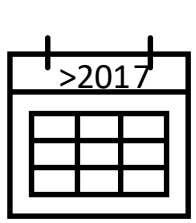
J Cardiothorac Vasc Anesth 2022. Doi: 10.1053/j.jvca.2022.03.030

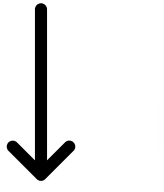
Impact of Processed Electroencephalography in Cardiac Surgery: A Retrospective Analysis





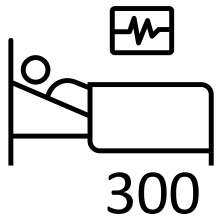


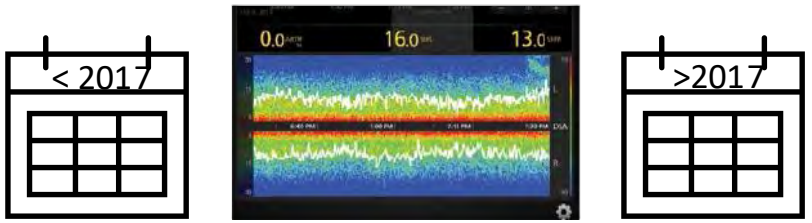




J Cardiothorac Vasc Anesth 2022. Doi: 10.1053/j.jvca.2022.03.030

Impact of Processed Electroencephalography in Cardiac Surgery: A Retrospective Analysis





Vasoactive inotropic score

Duration of intubation

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Journal of Cardiothoracic and Vascular Anesthesia 36 (2022) 3526–3528

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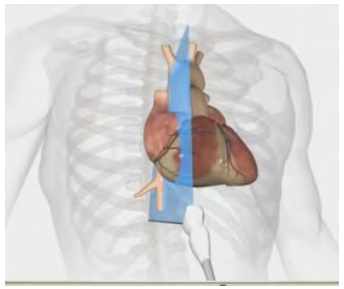
Editorial

EEG in Cardiac Surgery—Moving Past the Obvious

« The researchers described the potential of pEEG as a method to improve hemodynamic management and, consequently, additional postoperative outcomes. »

Richa Dhawan, MD, MPH

Department of Anesthesia and Critical Care,
University of Chicago Medical
Center, Chicago, IL



État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Choc Cardiogénique

- Obstructif
- Systolique
- Diastolique

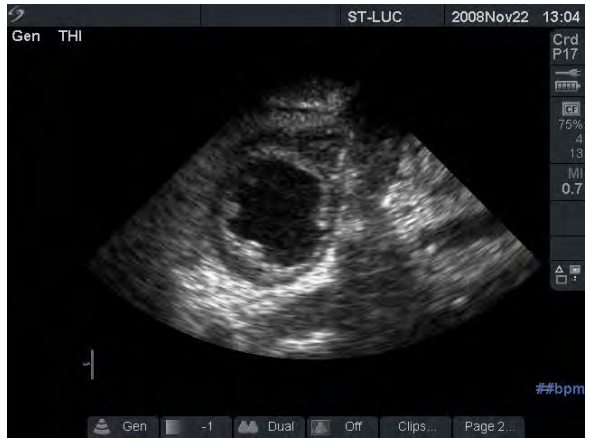
↑Pod

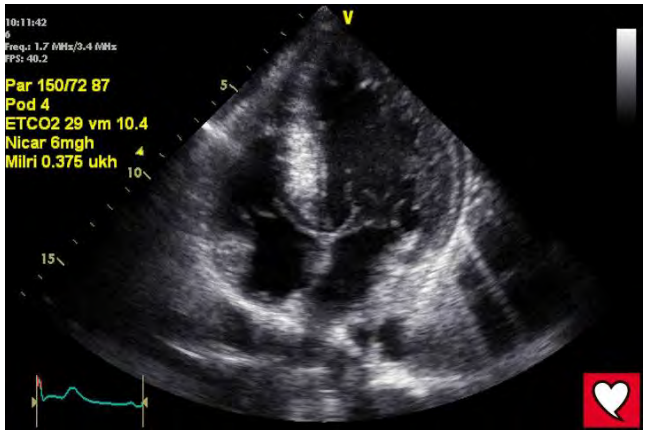
État de choc

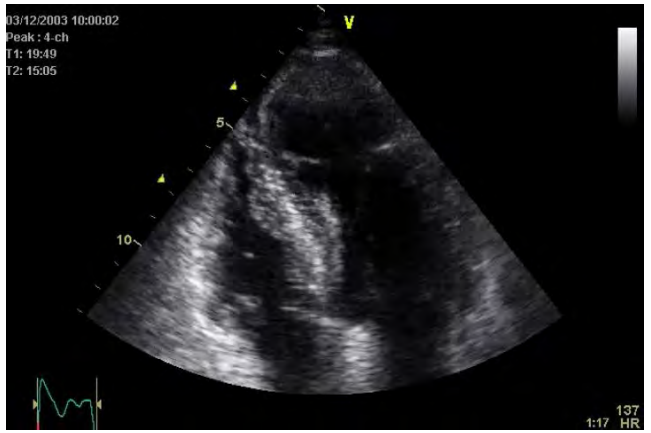
Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

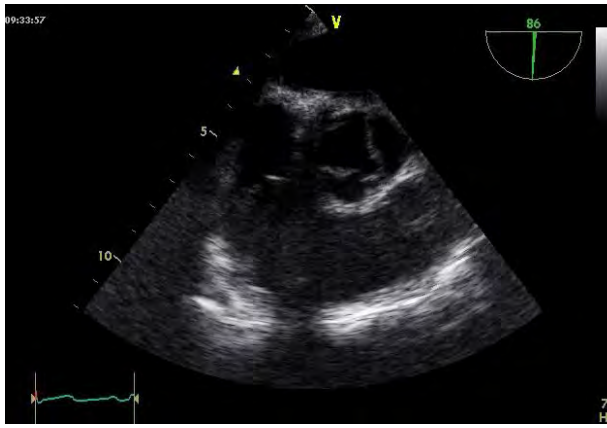
Choc Cardiogénique → Systolique

↑Pod

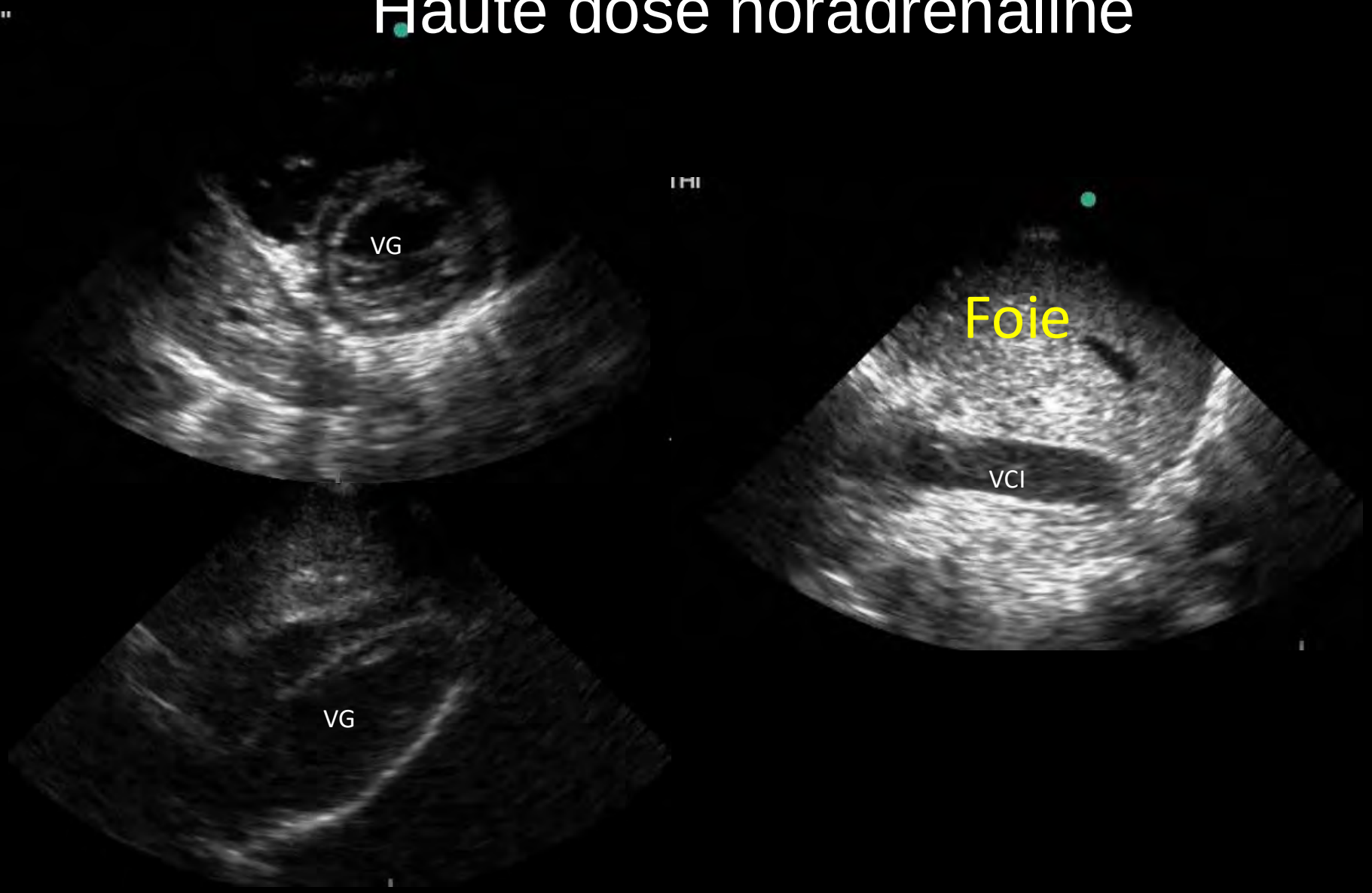




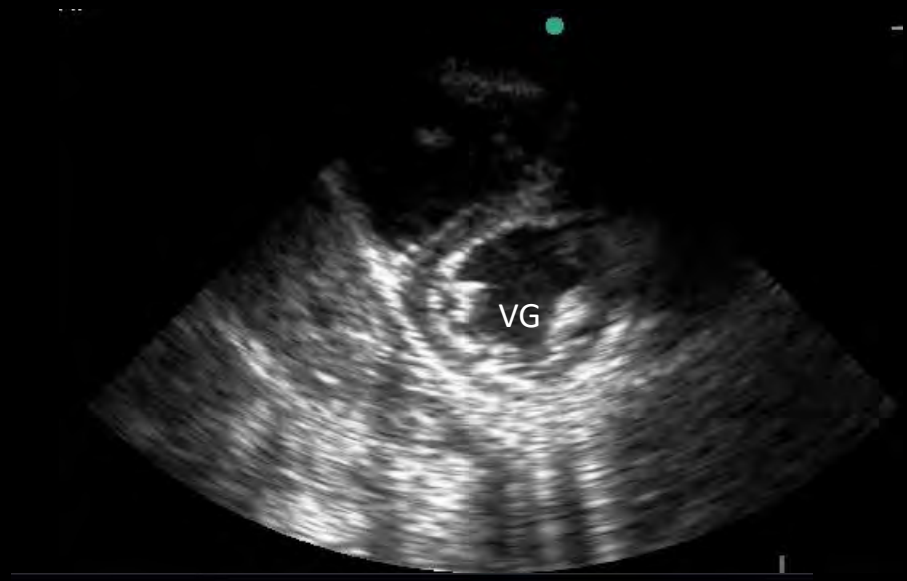


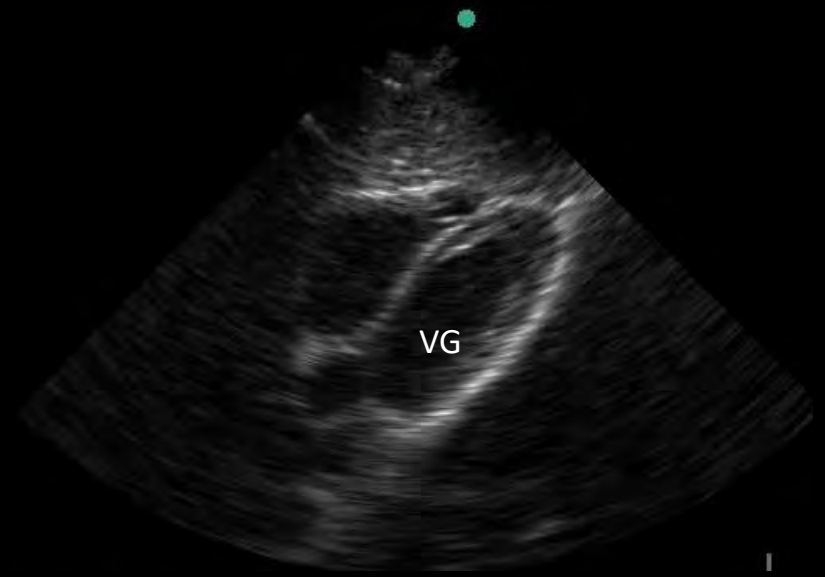


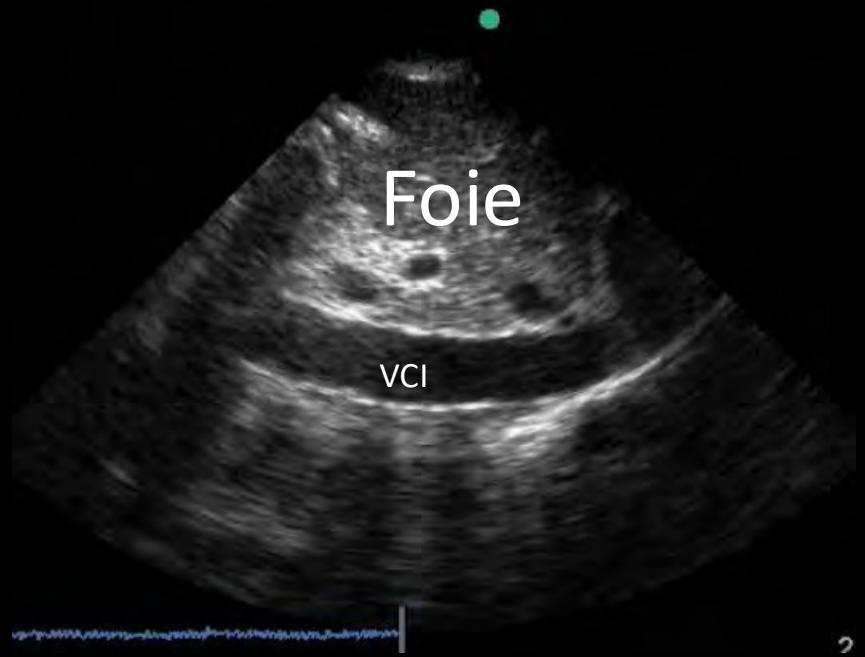
♂ 27 ans post-op laparotomie pour péritinite
Haute dose noradrénaline



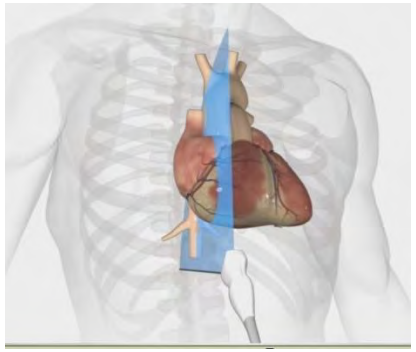
27 yo ♂ post-op laparotomy for peritonitis: after dobutamine

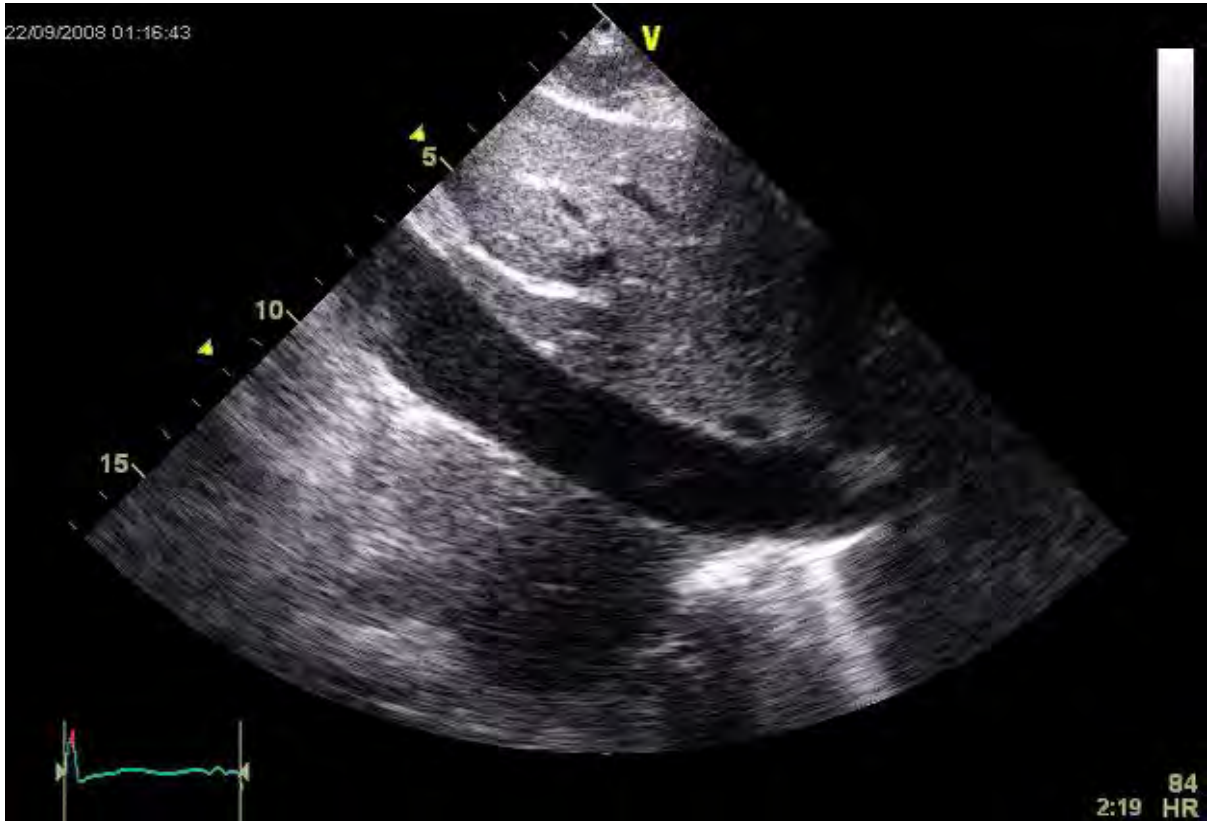


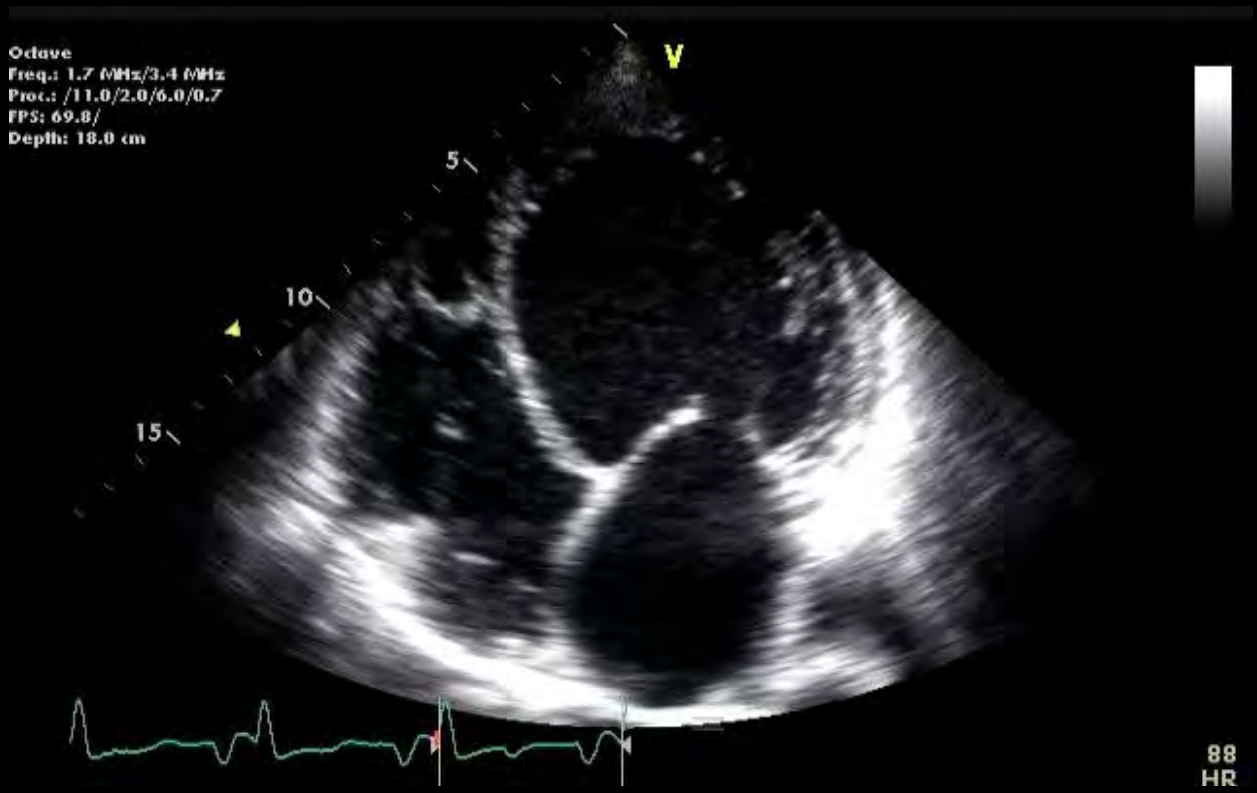


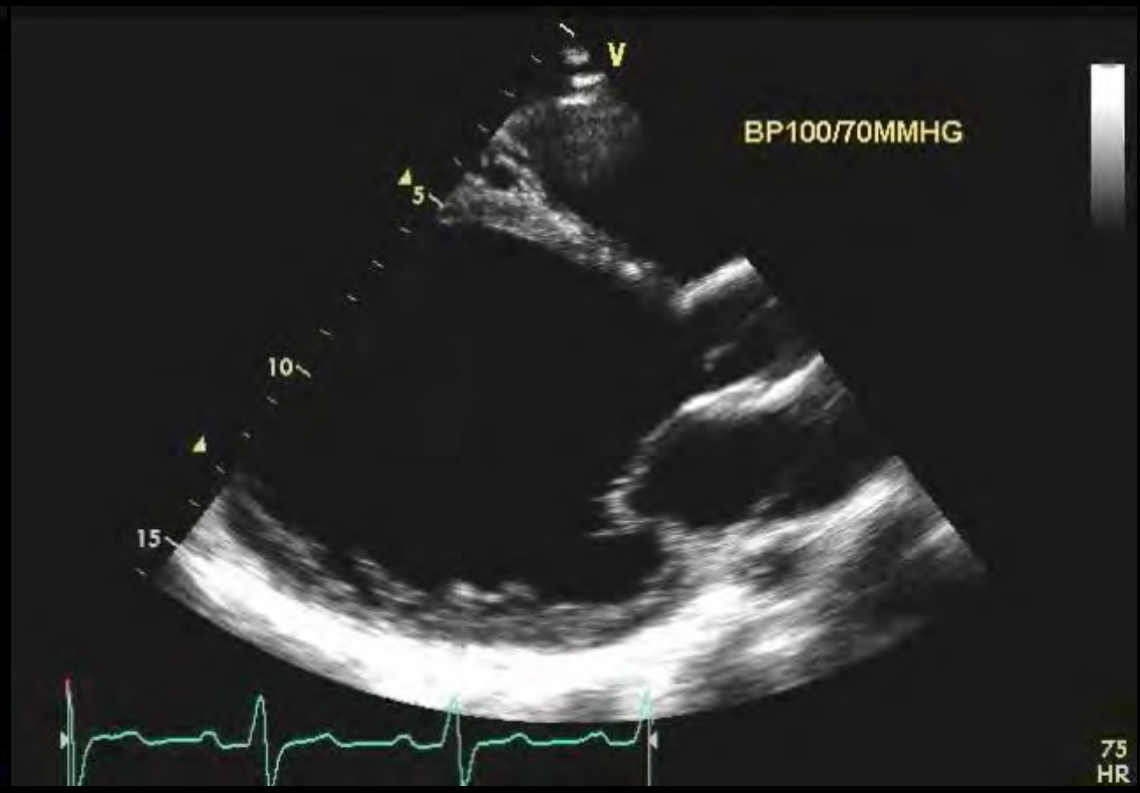


♂ 19 ans donneur d’organe: volume ou vasopresseur?

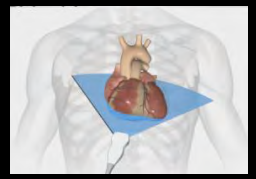





Octave
Freq.: 1.7 MHz/3.4 MHz
Proc.: /11.0/2.0/6.0/0.7
FPS: 69.8/
Depth: 18.0 cm
V
5
10
15
88
HR

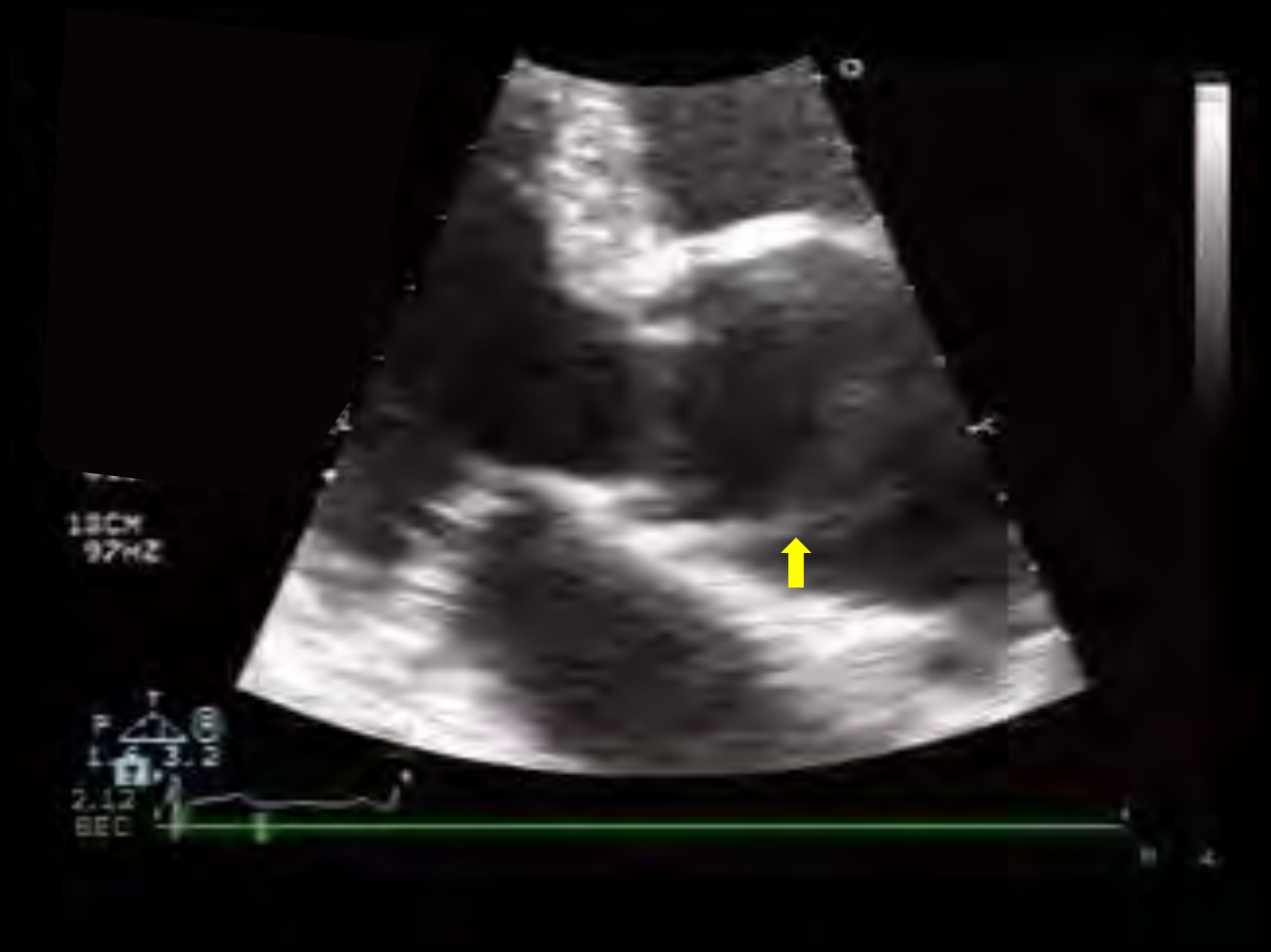

V
BP100/70MMHG
5
10
15
75
HR

Choc ♀ 36 ans en choc: perforation duodénale. Pourquoi?

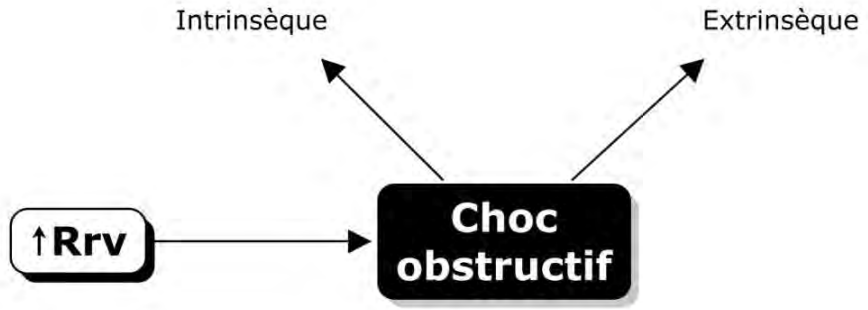


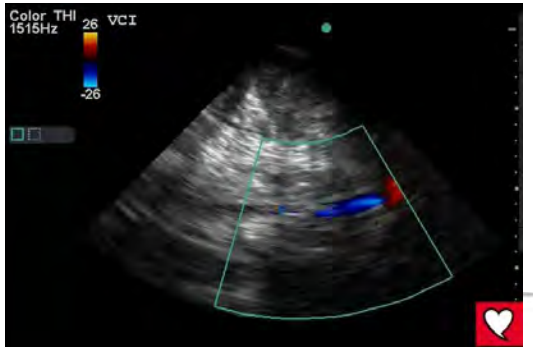
Instabilité hémodynamique et dyspnée 54 ans per broncoscopie

Instable pourquoi?



Limitations



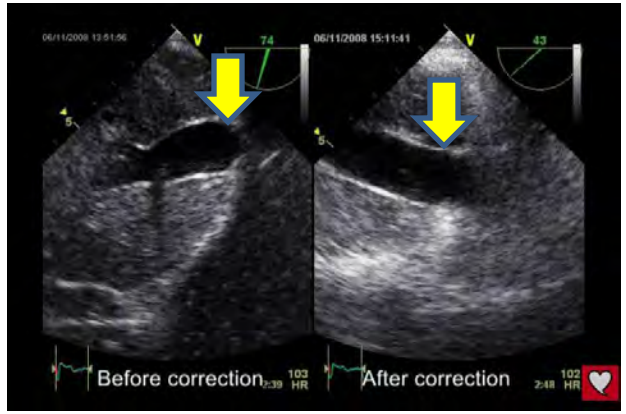


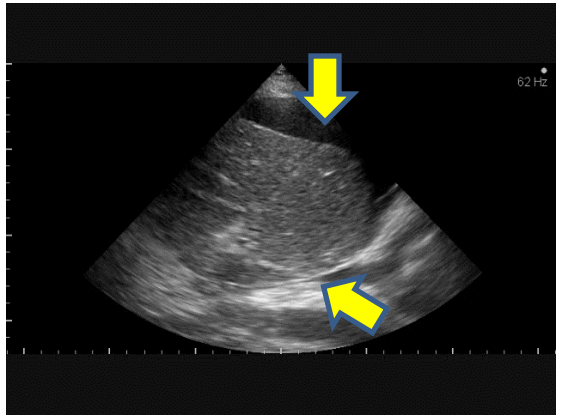
État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Infra-diaphragmatique

Supra-diaphragmatique



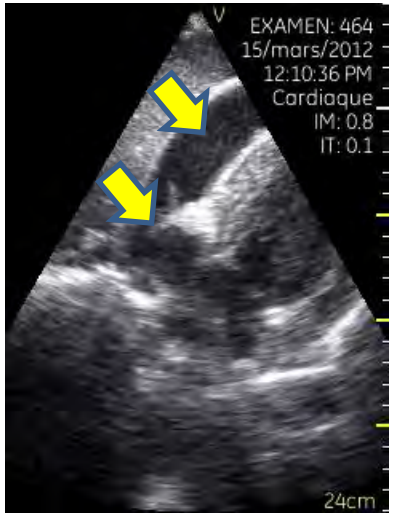


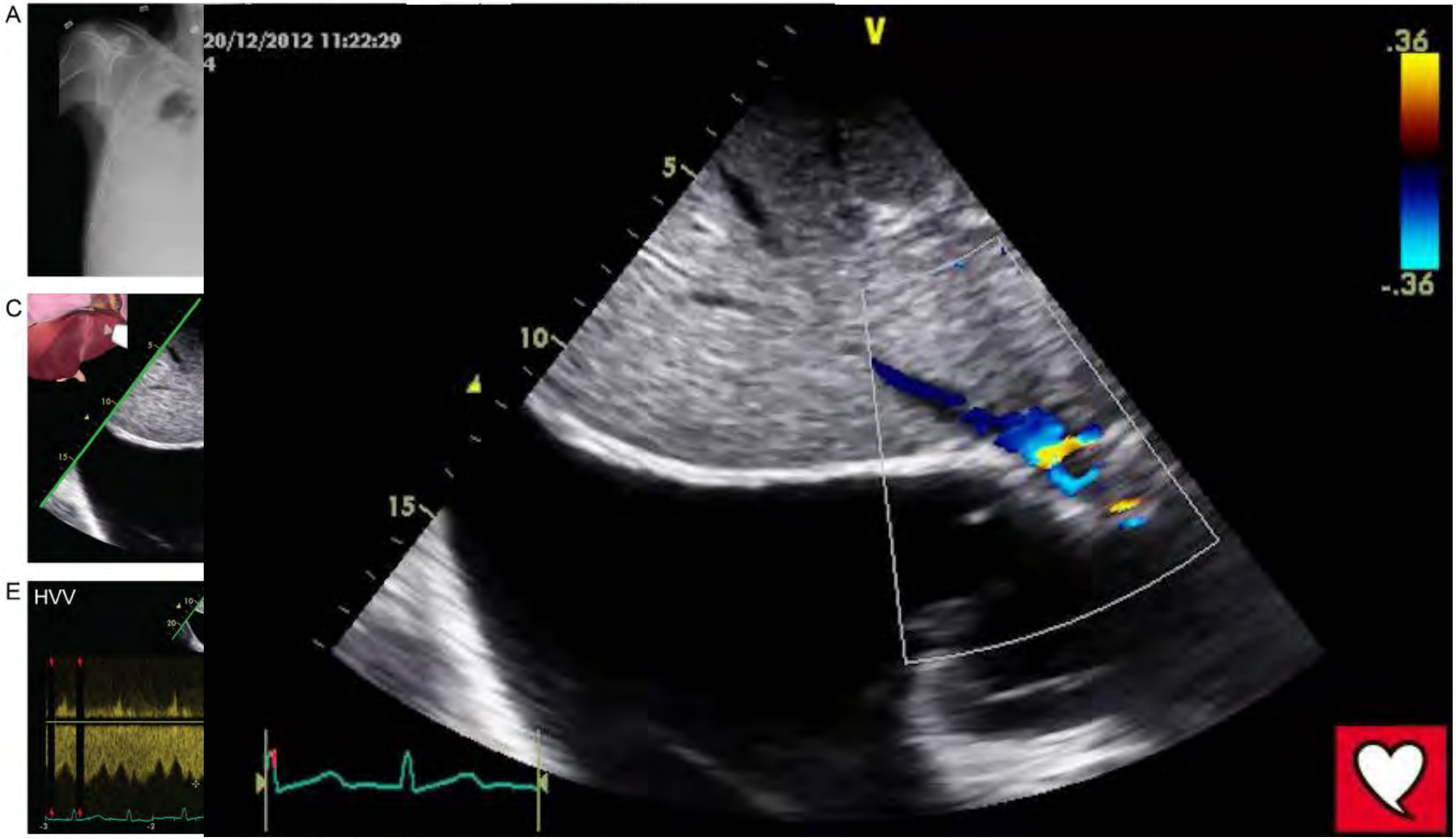
Intrinsèque

Extrinsèque

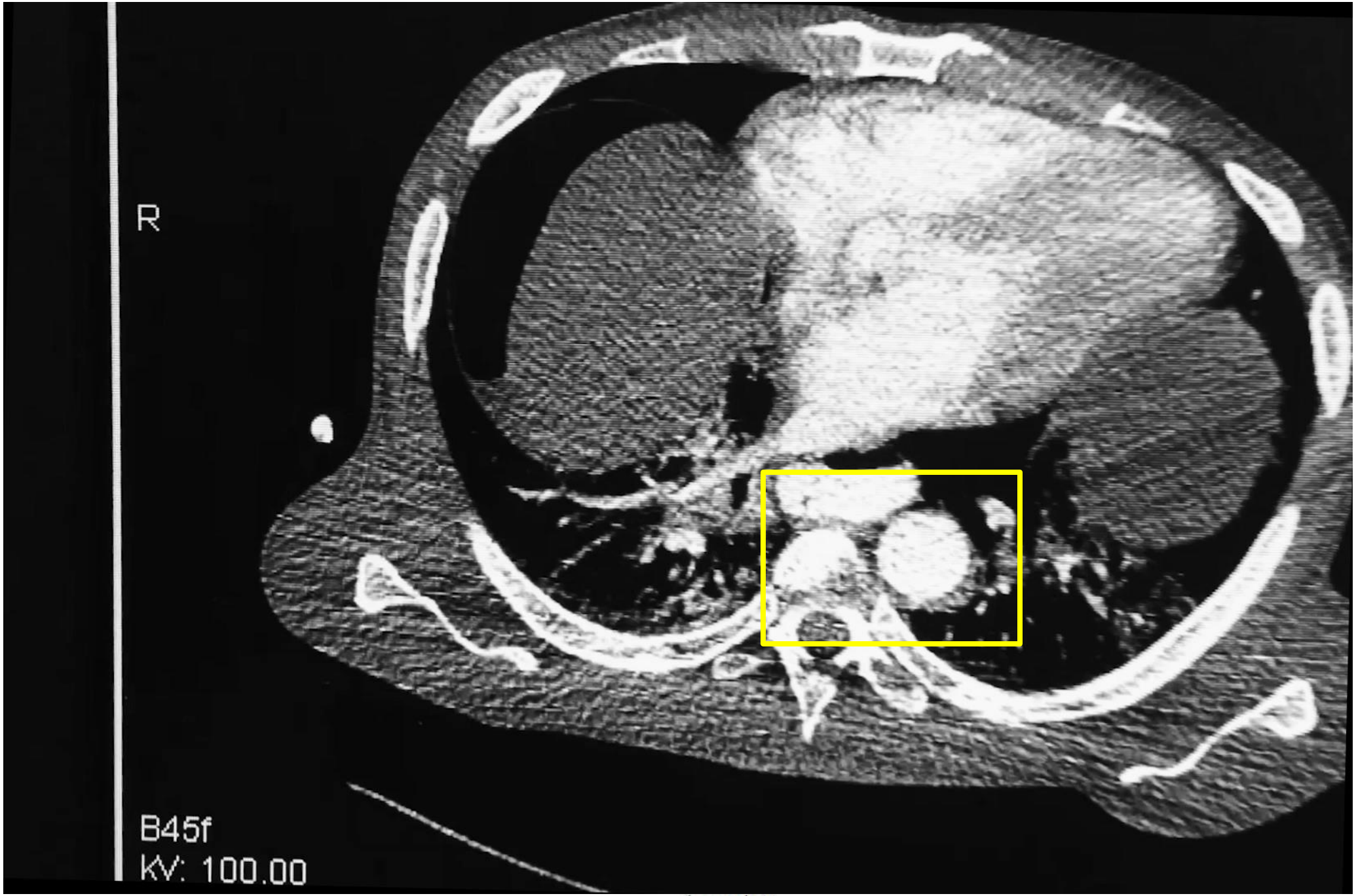
↑Rrv → **Choc obstructif**

État de choc





Chap 28 Fig 38



Chap 28 Fig 39

En résumé

État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Intrinsèque

Extrinsèque

↑Rrv

Choc obstructif

Pertes sanguines

État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Choc hypovolémique

Choc Cardiogénique

Obstructif

Systolique

Diastolique

Pertes non-sanguines

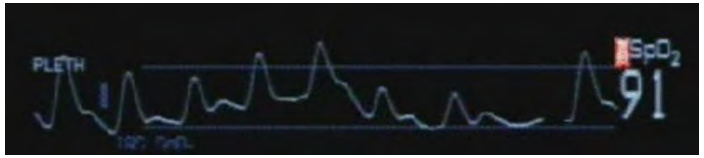
↓Pvs

Choc distributif

↑Pod

Septique

Non-septique



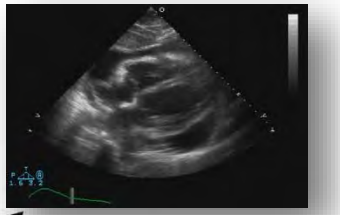
État de choc

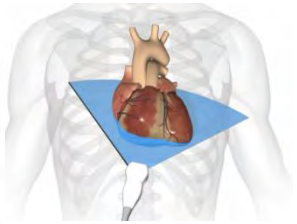
Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Choc obstructif

↑Rrv

Intrinsèque



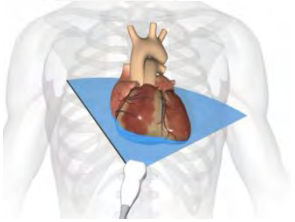


Obstructif

Choc Cardiogénique

↑Pod

Diastolique

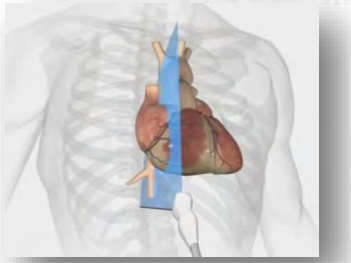


Choc hypovolémique

Pertes non-sanguines

↓Pvs

Choc distributif



Non-septique

État de choc

Hypotension
Oligurie
Extrémités froides
Altération neurologue
Acidose

Choc hypovolémique

↑Rrv

Intrinsèque

Choc obstructif

Pertes non-sanguines

Choc distributif

↓Pvs

Non-septique

Choc Cardiogénique

↑Pod

Obstructif

Diastolique

C-indiqué

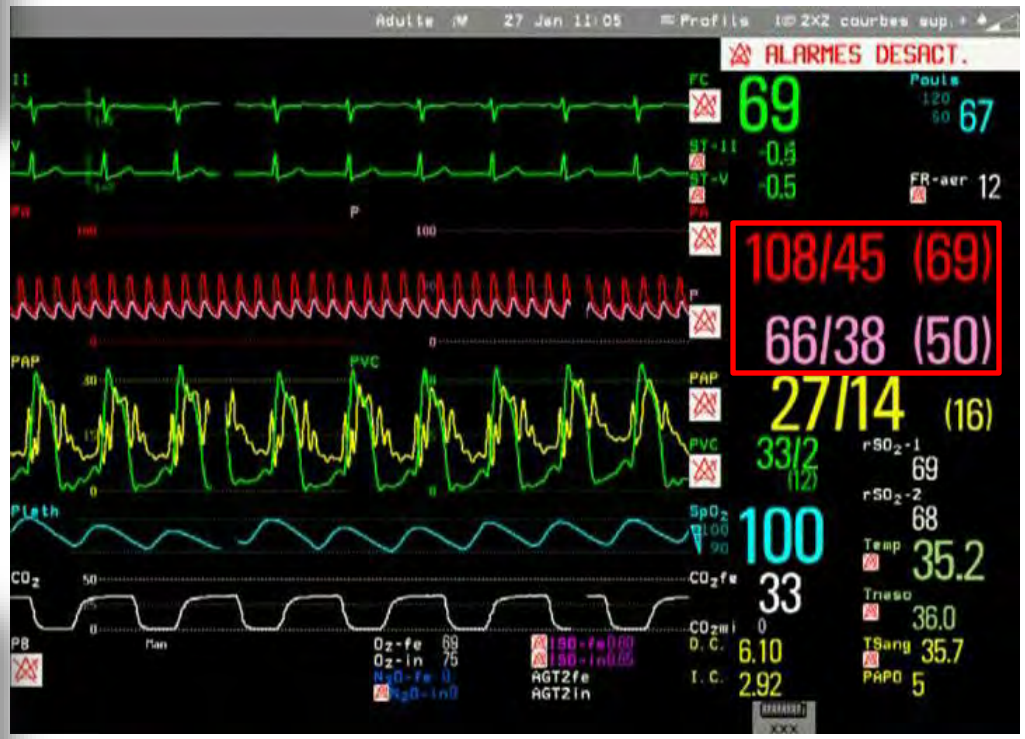

Milrinone
Lactate Injection
20 mg/20 mL*
(1 mg/mL)


USVET


Phenylephrine
HCl Injection USP
10 mg/mL

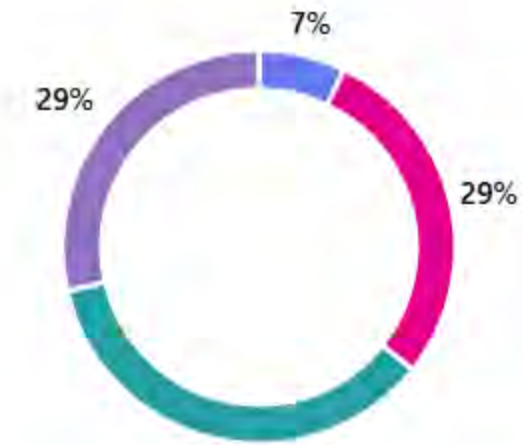

Levophed
norepinephrine bitartrate
injection, USP


0.9%
Sodium Chloride
Injection USP


Adulte
27 Jan 11:05
Profile
2x2 courbes sup
ALARMES DESACT.
FC
69
Pouls
67
ST-II
-0.5
ST-V
-0.5
FR-aer
12
108/45 (69)
66/38 (50)
PAP
PVC
27/14 (16)
33/2 (12)
rSO2-1
69
rSO2-2
68
Pleth
SpO2
100
CO2
CO2fe
33
Temp
35.2
Tnaso
36.0
TSang
35.7
PAPO
5
D.C.
6.10
I.C.
2.92
O2-fe 69
O2-in 75
AGT2fe
AGT2in

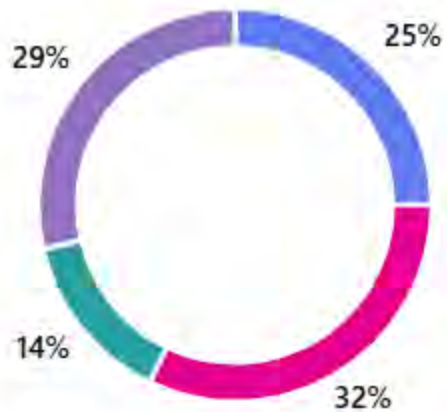
7. Obstruction des chambres de chasse (0 point)

A	2
B	8
C	10
D	8



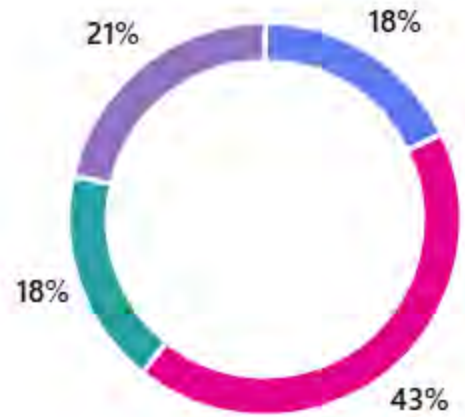
8. Gradient radial-fémoral (0 point)

A	7
B	9
C	4
D	8



10. Pression veineusesystémique (0 point)

A	5
B	12
C	5
D	6



11. Score VExUS (0 point)

A	15
B	5
C	5
D	3