Catheter de l'artère pulmonaire (Swan-Ganz)

COURS SCIENCES DE BASE - PROGRAMME D'ANESTHÉSIOLOGIE

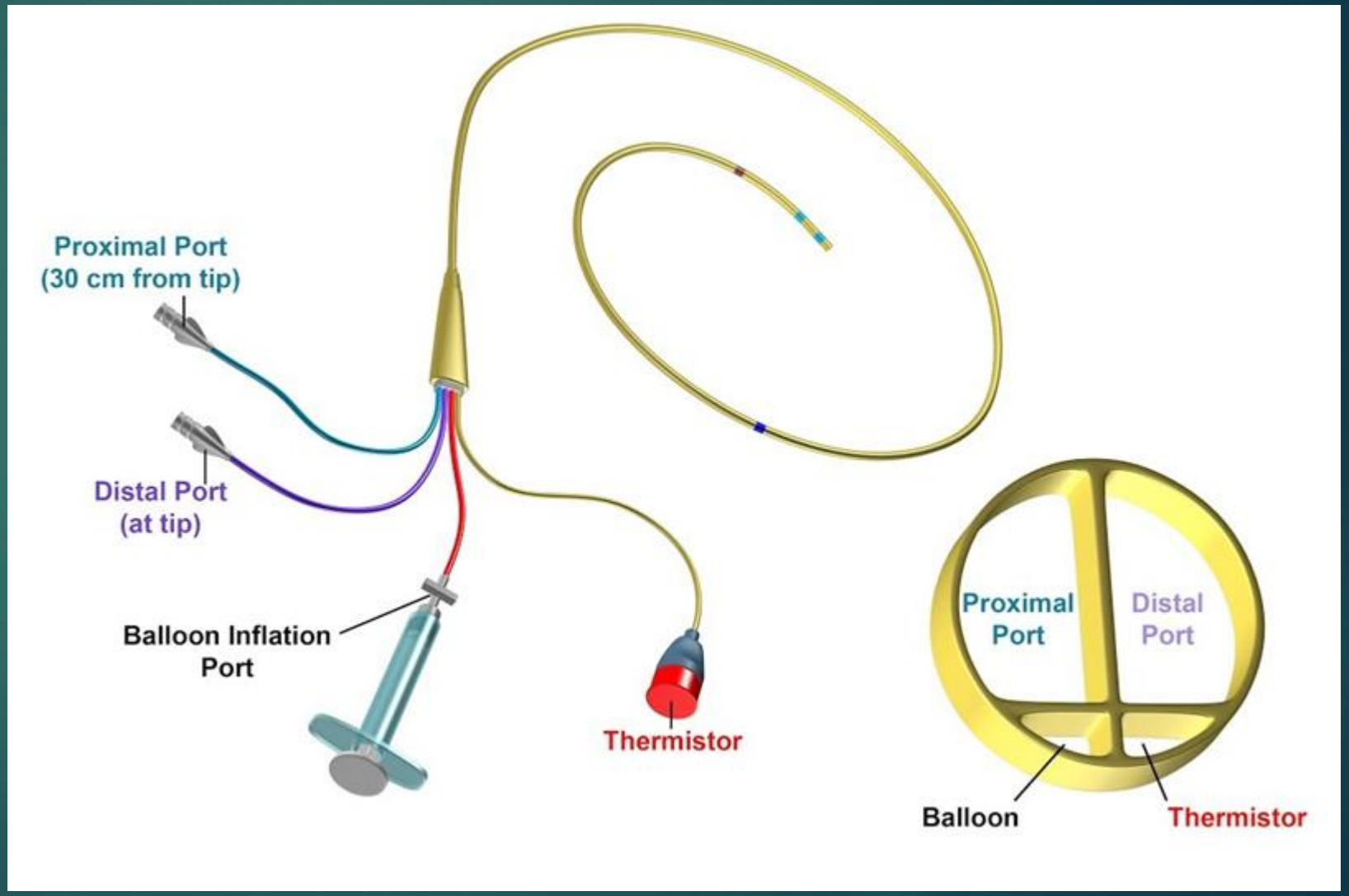
DRE MEGGIE RAYMOND 5 DÉCEMBRE 2019

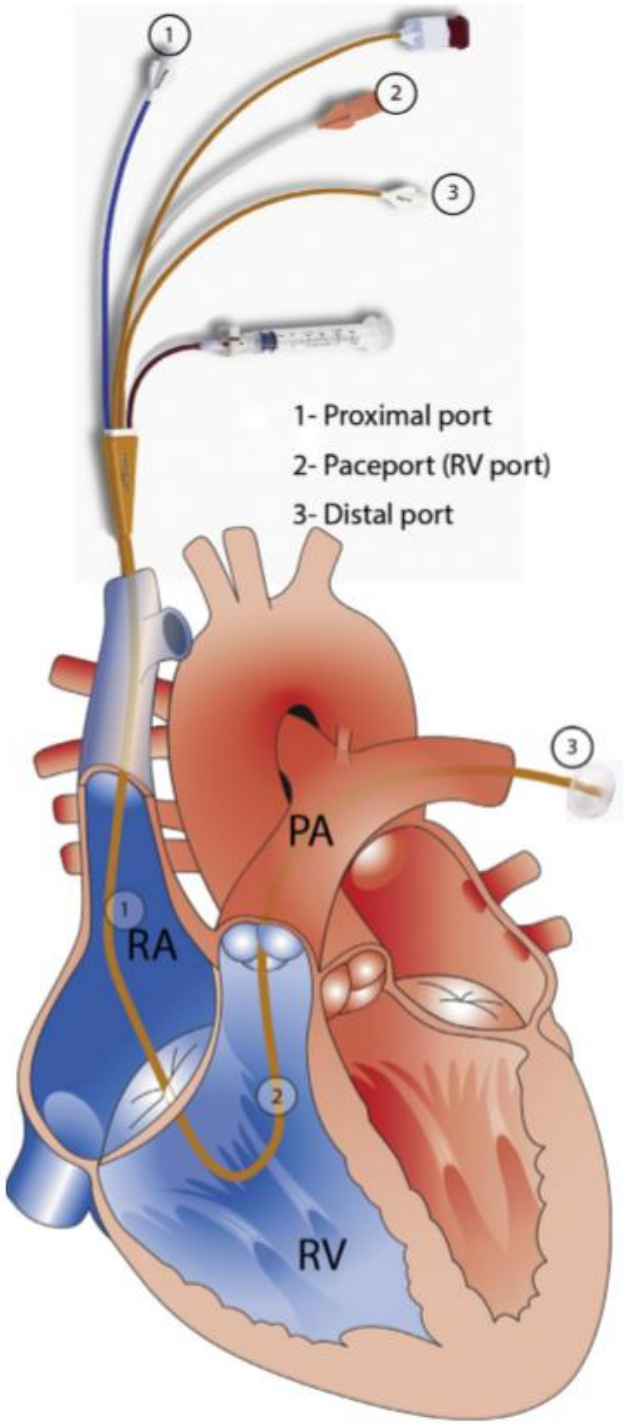
Objectifs

- Préparer et insérer un cathéter de l'artère pulmonaire
- Indications, limitations et complications
- Analyser variables hémodynamiques cœur droit (TVC, PAP, Wedge, D.C.)
- Interpréter les gaz veineux centraux (SvO2/ScvO2)
- Déterminer livraison et consommation O2 corporelle
- Questions d'examen 

Qu'est-ce qu'un Swan-Ganz?

- cathéter 110 cm
- 7-9 Fr de circonférence
- Possible sans latex




1
2
3
1- Proximal port
2- Paceport (RV port)
3- Distal port
PA
RA
RV

Préparer et insérer un Swan-Ganz

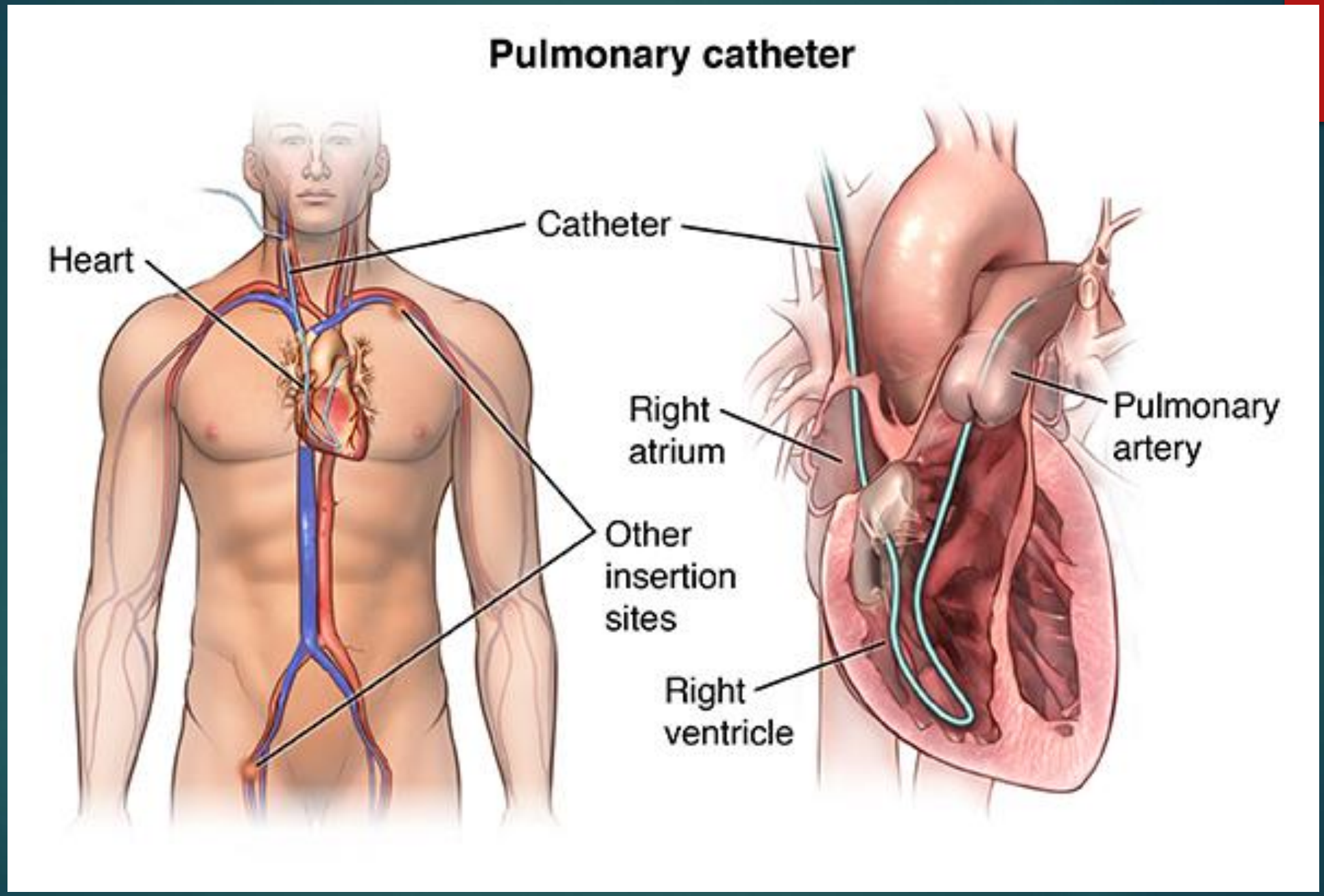
- Présence d'un assistant
- Technique stérile voie centrale, échoguidance, etc.

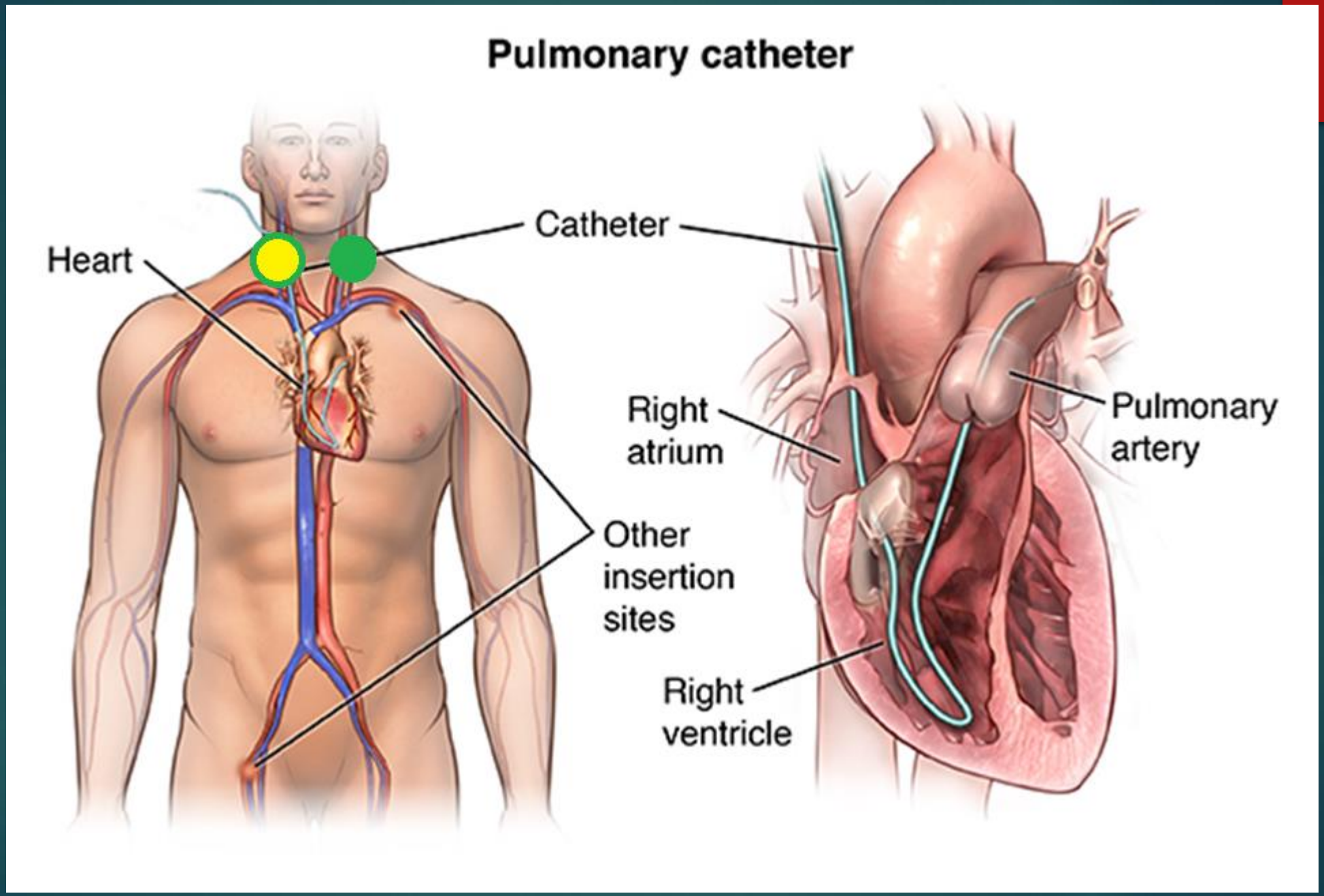
Préparer et insérer un PAC

- Insérer via introducteur

Préparer et insérer un PAC

- Présence d'un assistant
- Technique stérile voie centrale, échoguidance, etc.
- Choix de veine


Pulmonary catheter
Heart
Catheter
Other insertion sites
Right atrium
Pulmonary artery
Right ventricle


Pulmonary catheter
Heart
Catheter
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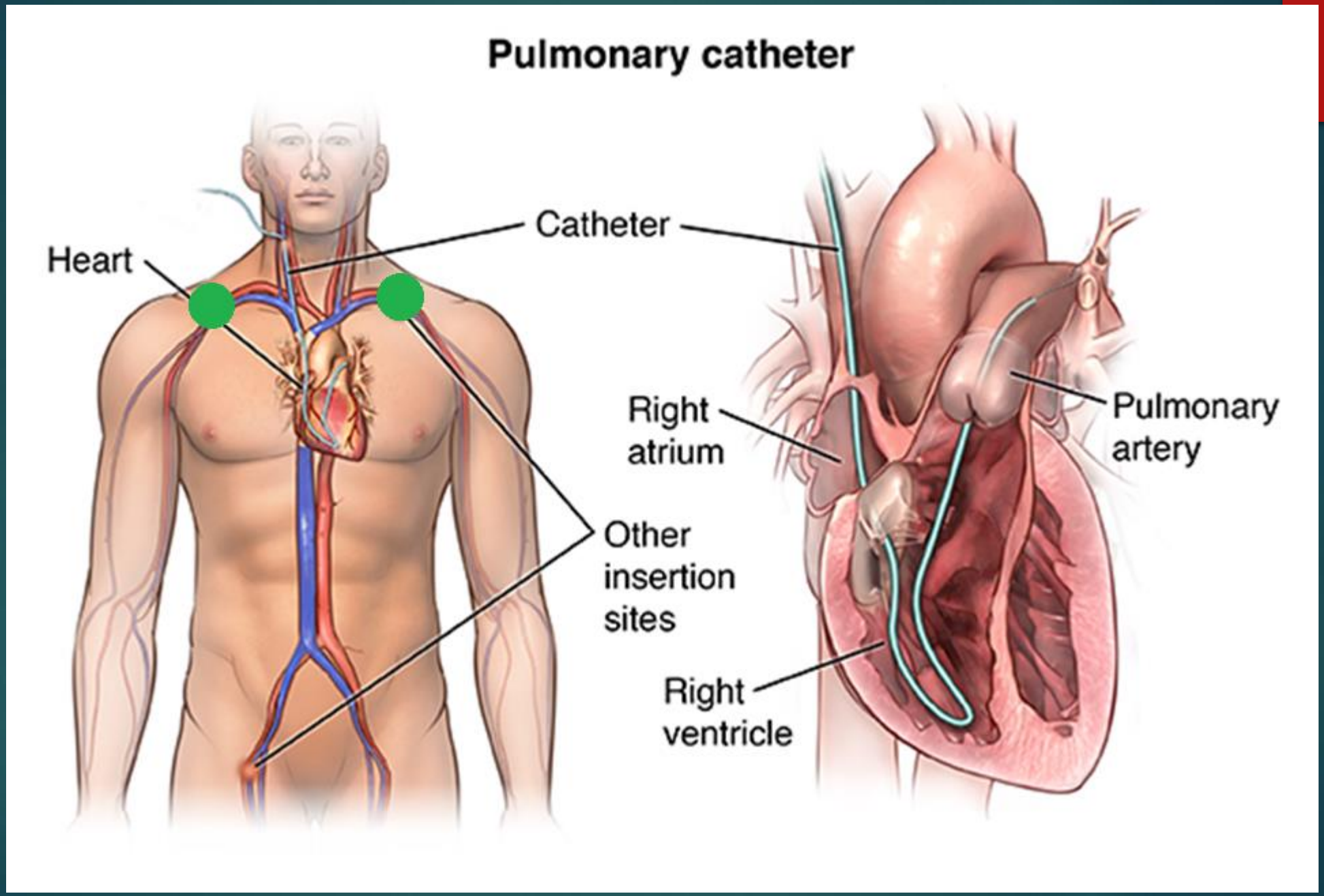
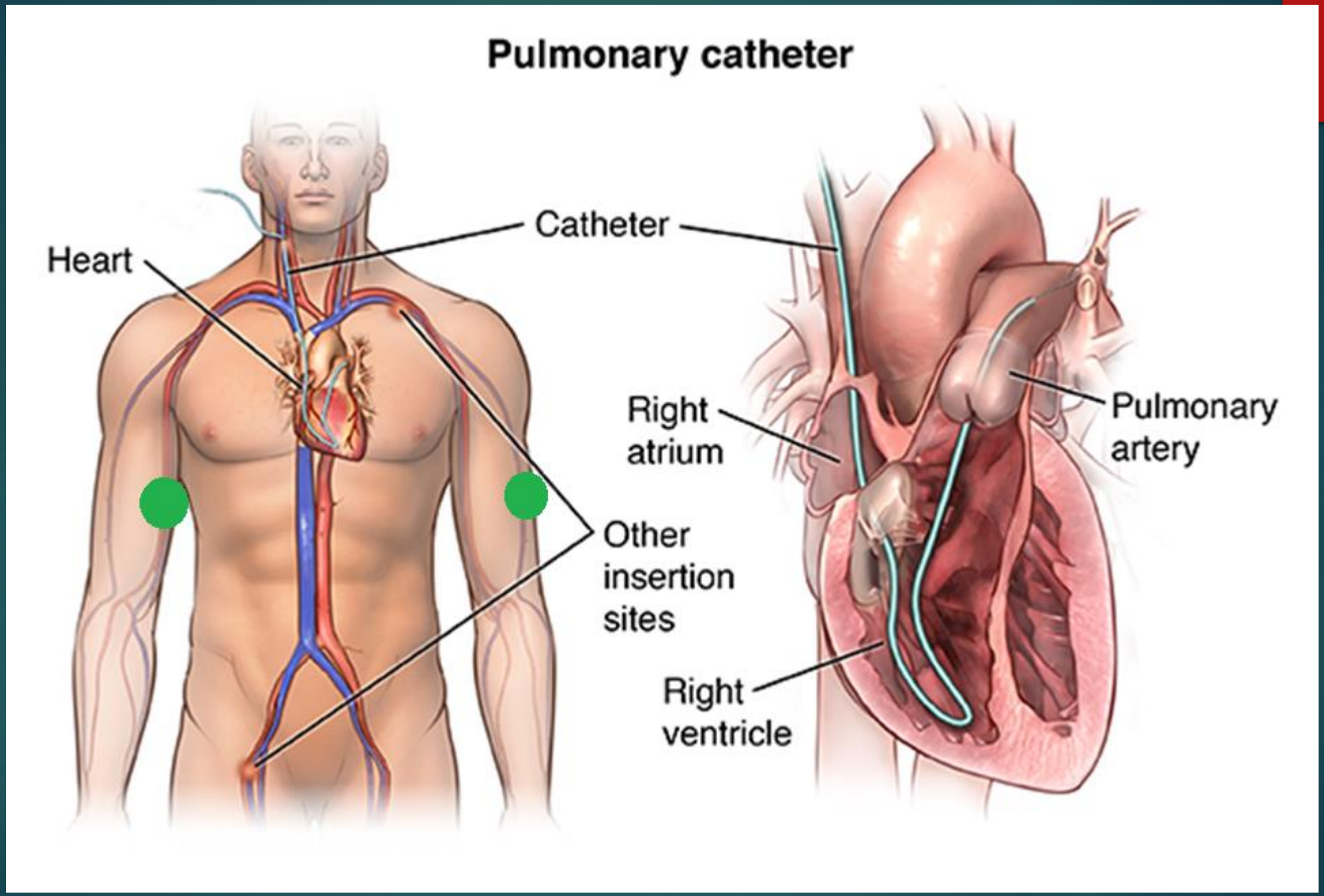
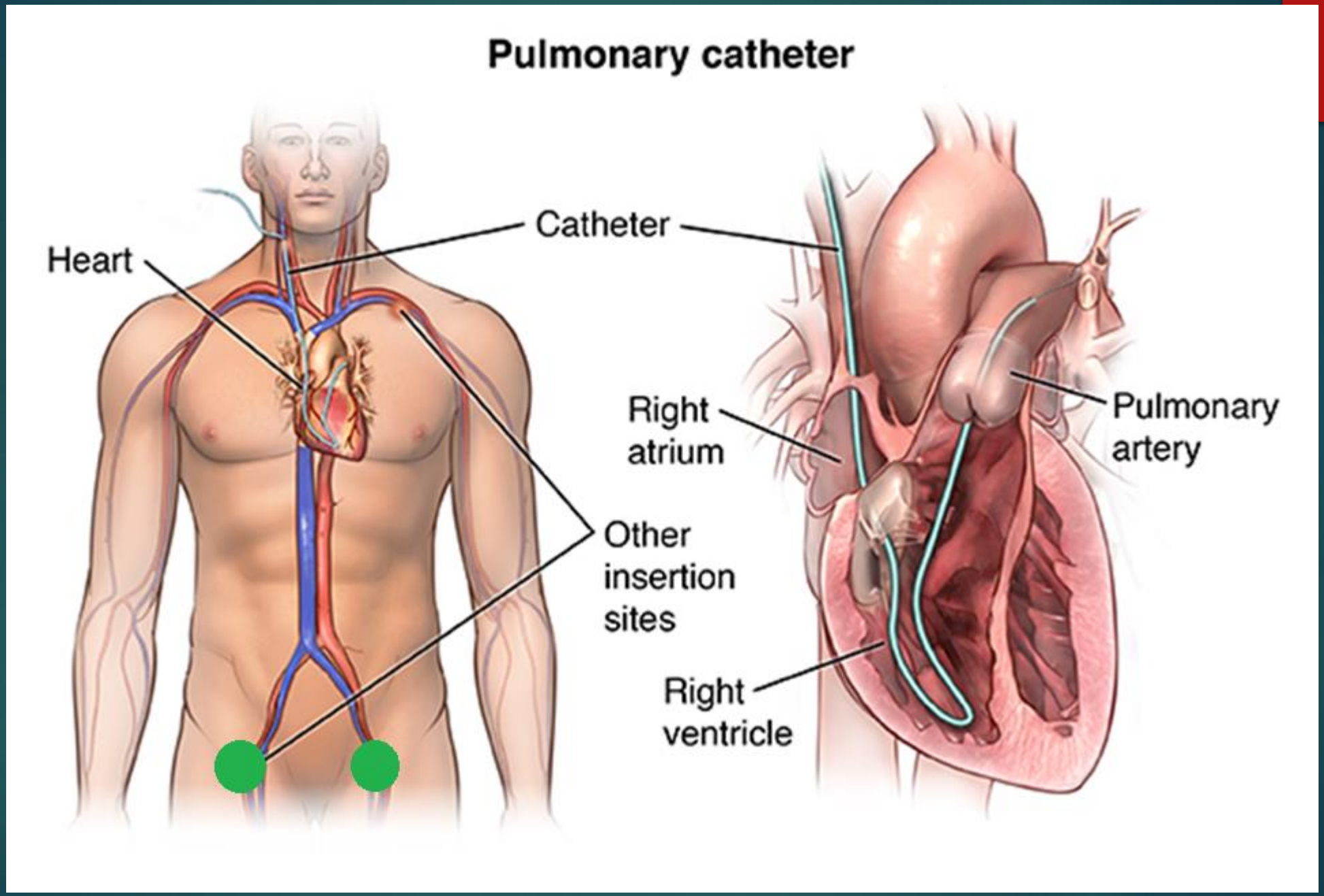
Pulmonary artery
Right ventricle

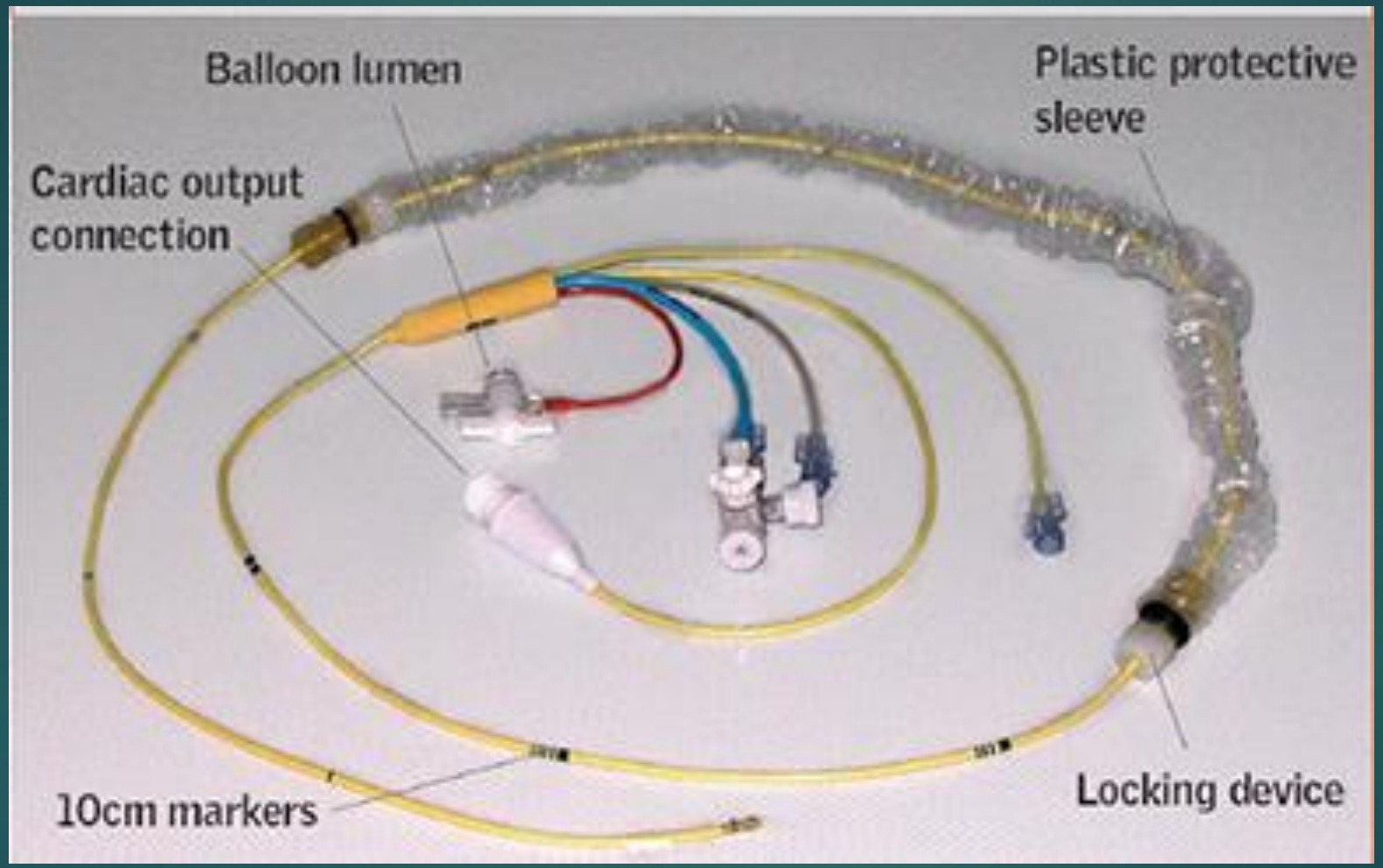

Pulmonary catheter
Heart
Catheter
Other insertion sites
Right atrium
Pulmonary artery
Right ventricle


Pulmonary catheter
Heart
Catheter
Other insertion sites
Right atrium
Pulmonary artery
Right ventricle


Pulmonary catheter
Heart
Catheter
Other insertion sites
Right atrium
Pulmonary artery
Right ventricle

Préparer et insérer un PAC

- Présence d'un assistant
- Technique stérile voie centrale, échoguidance, etc.
- Choix de veine
- Table de Swan :
  - Gaine stérile en premier, observer les marqueurs aux 10 cm
  - Tester ballon, laisser dégonfler seul

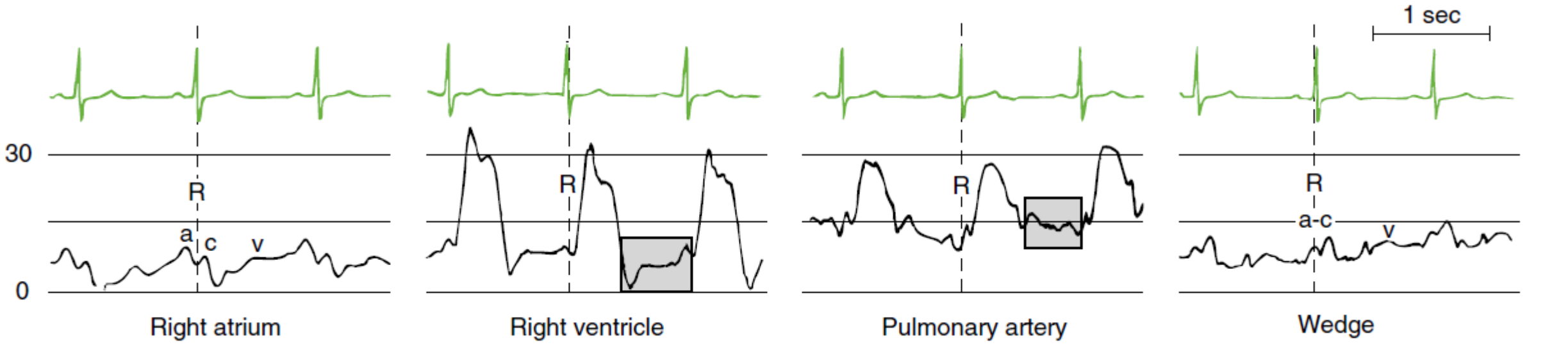

Balloon lumen
Plastic protective sleeve
Cardiac output connection
10cm markers
Locking device

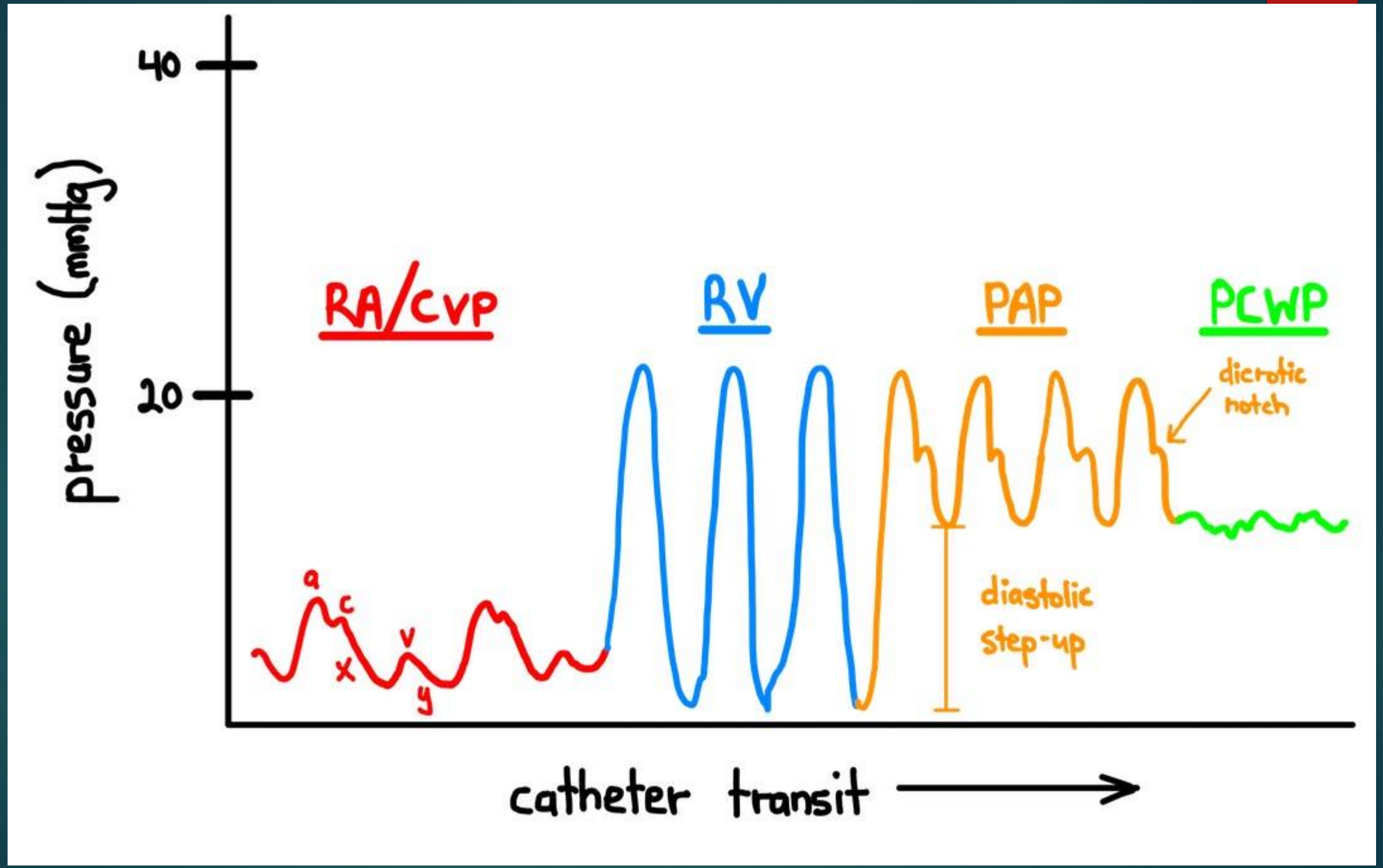
Préparer et insérer un Swan-Ganz

- Présence d'un assistant
- Technique stérile voie centrale, échoguidance, etc.
- Choix de veine
- Table de Swan :
  - Gaine stérile en premier
  - Tester ballon, laisser dégonfler seul
  - Connecter lignes de pression, faire le vide avec salin
  - Maintenir cathéter au niveau du cœur et bouger de bas en haut et voir si la pression sur le moniteur correspond
  - Insertion avec monitoring hémodynamique, échelles à 50 mmHg
    - Scopie
    - ETO

Insertion Swan-Ganz

- Insérer à 20 cm
- Gonfler ballon
- Avancer le Swan
- JID : OD environ 20-25 cm, ventricule droit 30-35 cm, PAP 40-45 cm, wedge 45-55 cm
- Site alternatif : ajouter
  - 5-10 cm JIG, JED et JEG
  - 15 cm veine fémorale
  - 30-35 cm veine antécubitale
- Radiographie (bout 2 cm silhouette cardiaque)


1 sec
30
0
R
a
c
v
R
R
R
a-c
v
Right atrium
Right ventricle
Pulmonary artery
Wedge


40
20
pressure (mmHg)
RA/CVP
RV
PAP
PCWP
dicrotic notch
diastolic step-up
a
c
x
v
y
catheter transit

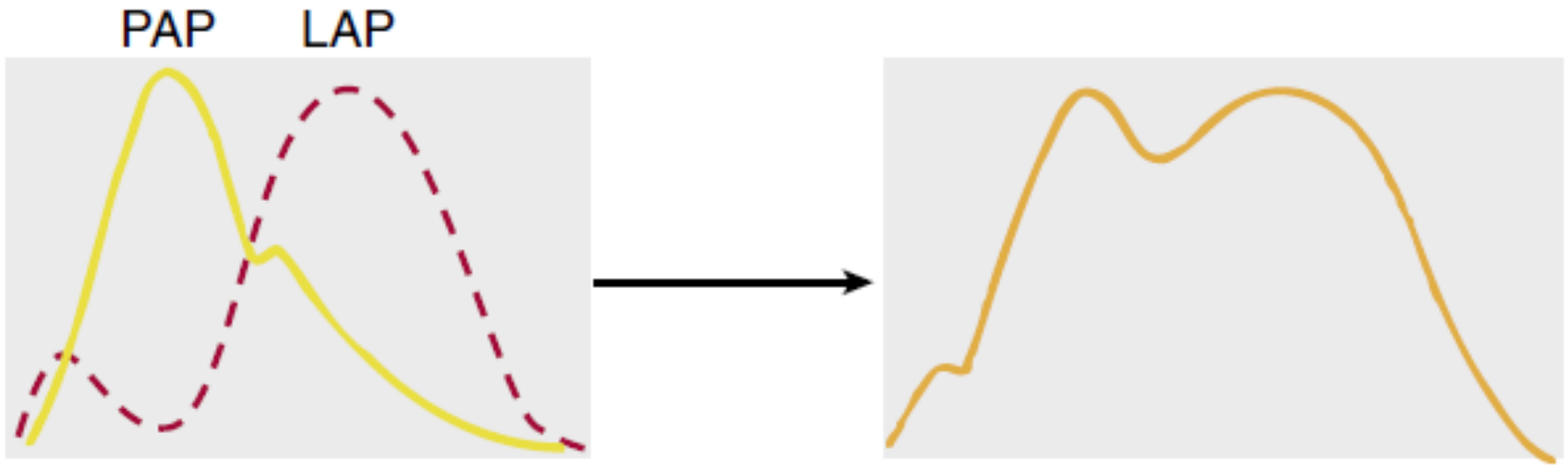
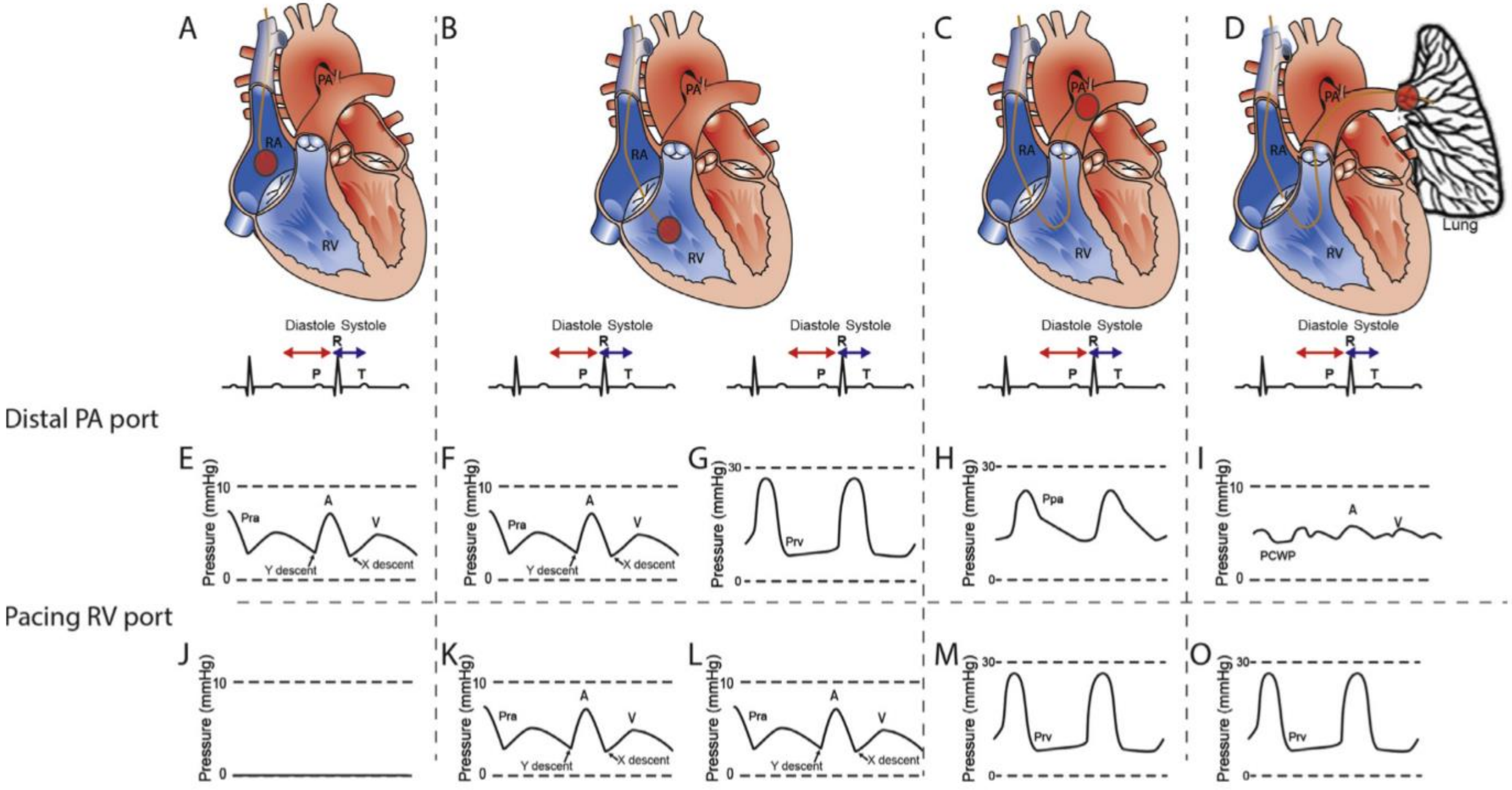


Figure 40-30 Tall left atrial pressure (LAP) a and v waves transmitted in a retrograde direction through the pulmonary vasculature distort the antegrade pulmonary artery pressure (PAP) waveform. The LAP a wave distorts the systolic upstroke, and the v wave distorts the dicrotic notch. *(From Mark JB: Atlas of Cardiovascular Monitoring. New York, Churchill Livingstone, 1998, Fig. 4-10.)*


A
B
C
D
PA
RA
RV
Lung
Diastole Systole
R
P
T
Distal PA port
Pacing RV port
E
F
G
H
I
J
K
L
M
O
Pressure (mmHg)
10
30
0
Pra
A
V
Y descent
X descent
Prv
Ppa
PCWP

Comment s'aider à l'insertion?

- Position « Swan » de la table d'opération : Trendelenburg pour passer VT, puis « fowler » + latéral droit → ballon flotte ira vers CCVD
- Apnée ou respiration profonde en spontané
- Avancer avec battements cardiaques
- Garder courbure naturelle du cathéter et l'orienter vers la CCVD
- Retiré et « reflusher » (aidera à reprendre forme) avec liquide froid
- Faire vrilles en insérant
- Attendre thorax ouvert
- Demander au patron. Si tu es le patron, considère d'abandonner la technique 

Complications

- Complications liées voie centrale

Box 40-5 Complications of Central Venous Pressure Monitoring

- Mechanical
  - Vascular injury
    - Arterial
    - Venous
    - Hemothorax
    - Cardiac tamponade
  - Respiratory compromise
    - Airway compression from hematoma
    - Tracheal, laryngeal injury
    - Pneumothorax
  - Nerve injury
  - Arrhythmias
  - Subcutaneous/mediastinal emphysema
- Thromboembolic
  - Venous thrombosis
  - Pulmonary embolism
  - Arterial thrombosis and embolism (air, clot)
  - Catheter or guidewire embolism
- Infectious
  - Insertion site infection
  - Catheter infection
  - Bloodstream infection
  - Endocarditis
- Misinterpretation of data
- Misuse of equipment

Complications – Contre-indications

- Complications liées voie centrale
- Mauvaise interprétation
- Mauvais utilisation équipement
- Insertion :
  - Arythmie, FV, BBD, BAV complet
- Nœud dans cathéter, cathéter coincé par sutures
- Thrombo-embolie
- Infarctus pulmonaire
- Infection, EI
- Dommage intra-cardiaque, lésion valvulaire
- Rupture artère pulmonaire : hémorragie létale
- Pseudoanévrysme artère pulmonaire

- CI relatives :
  - Procédure de Ross
  - CIA, CIV
  - Chirurgie cœur droit (ex valve tricuspide)
  - Cœur mécanique (Cardiowest)

- Complications mineures > 50%
- Complications graves 0,1-0,5%

Précautions

- Le moins de manipulation possible, pas toujours nécessaire de faire le wedge
- Gaine stérile mais pas impossible d'être contaminée
- Ne pas insérer trop loin
- Air dans ballon et non liquide
- Toujours vérifier position avant de gonfler ballon
  - cathéter peut migrer distalement et être « wedgé » même si ballon dégonflé, surtout après CEC : **reconnaître position de wedge ou NE PAS Wedger**

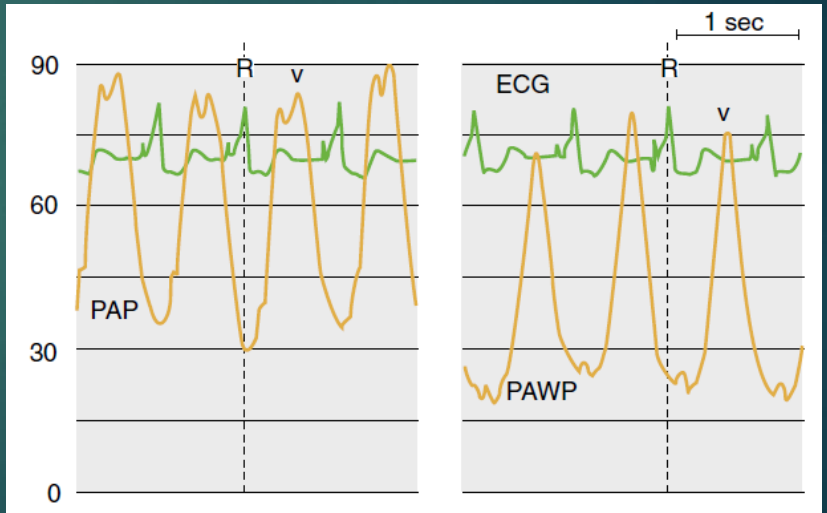
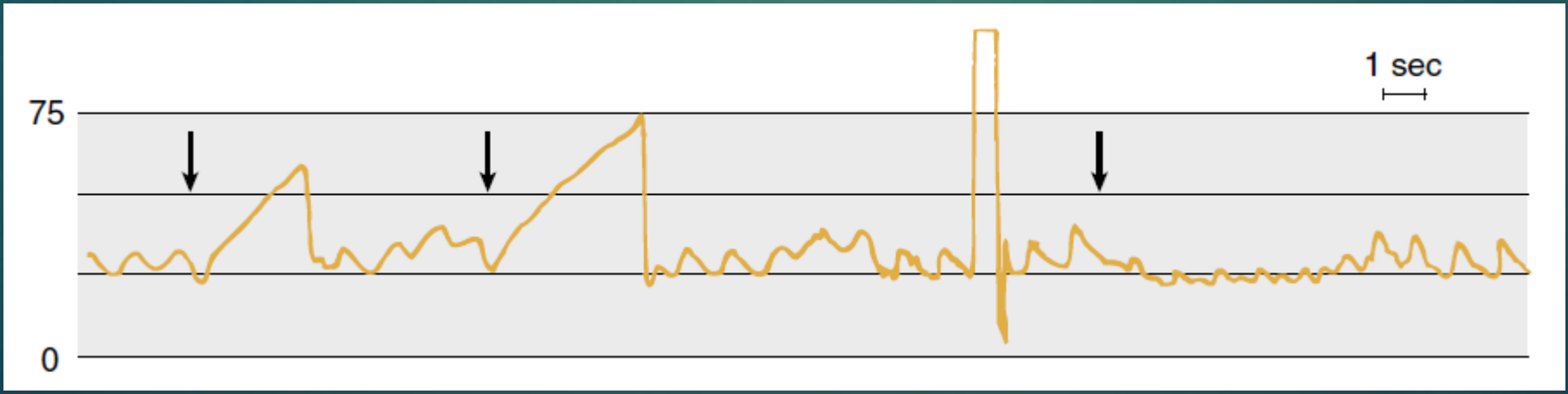


Figure 40-34 Severe mitral regurgitation. A tall systolic v wave is inscribed in the pulmonary artery wedge pressure (PAWP) trace and also distorts the pulmonary artery pressure (PAP) trace, thereby giving it a bifid appearance.

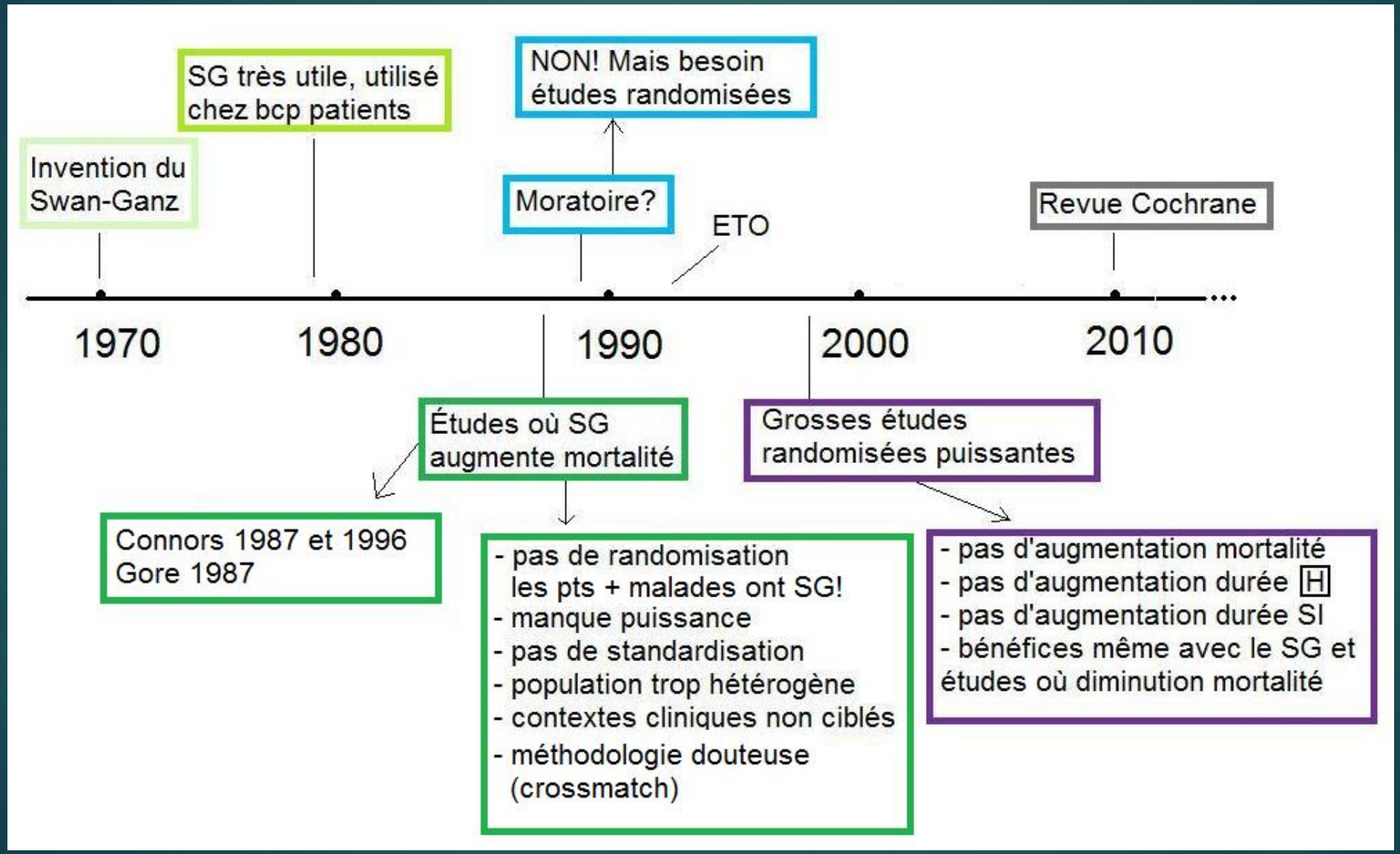
Précautions

- Vérifier mobilité Swan fin cas
- Si difficile à insérer, penser veine cave gauche supérieure persistante ou absence VCSD
- Retirer le cathéter ballon dégonflé
- Ne pas avancer si « overwedging »



Swan versus pas de Swan?

Une controverse qui vient de loin…



Cathéter artère pulmonaire selon Cochrane

- Pas de différence de mortalité Swan vs Ø Swan
- Pas d'augmentation durée hospitalisation ni soins intensifs
- En général, plus $ dans les groupes Swan
- Conclusion : des études d'efficacité sont nécessaires pour déceler les patients qui bénéficieraient du Swan

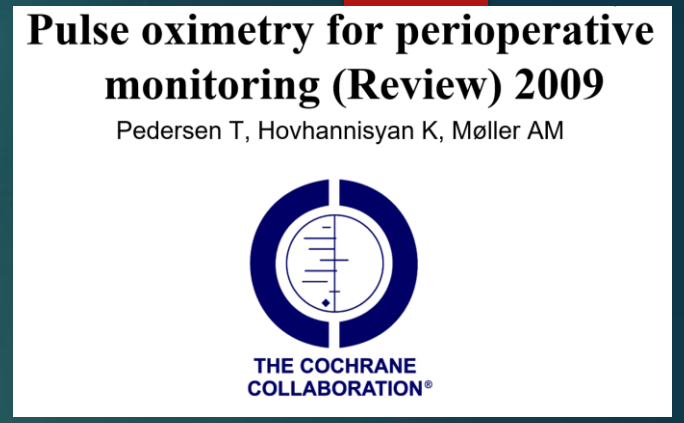
Pulmonary artery catheters for adult patients in intensive care (Review)

Harvey S, Young D, Brampton W, Cooper A, Doig GS, Sibbald W, Rowan K

THE COCHRANE COLLABORATION®

The Cochrane Library 2010, Issue 7

Mortalité et Swan

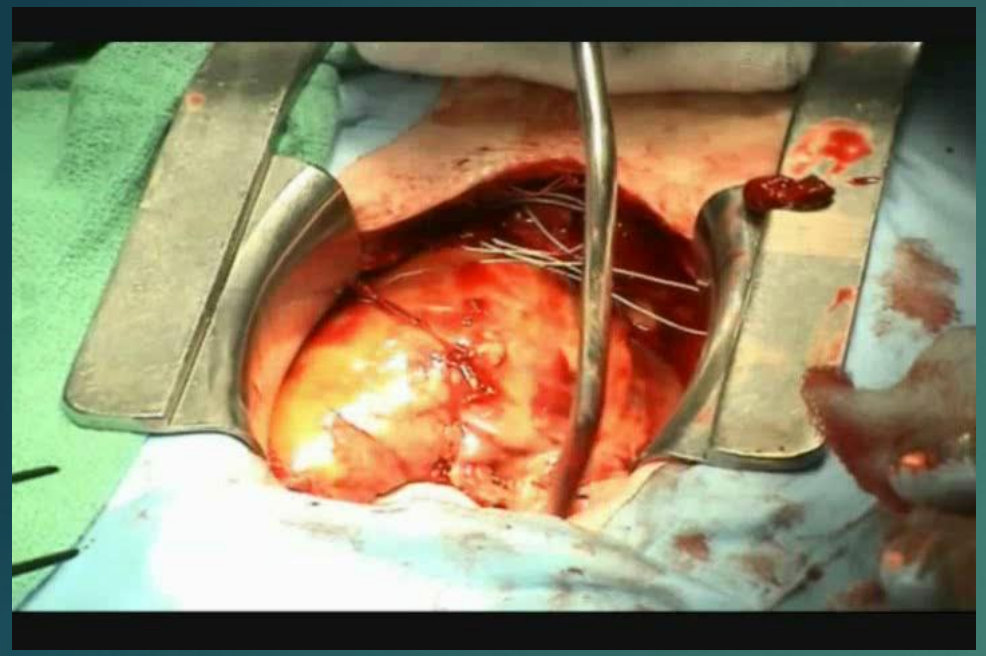


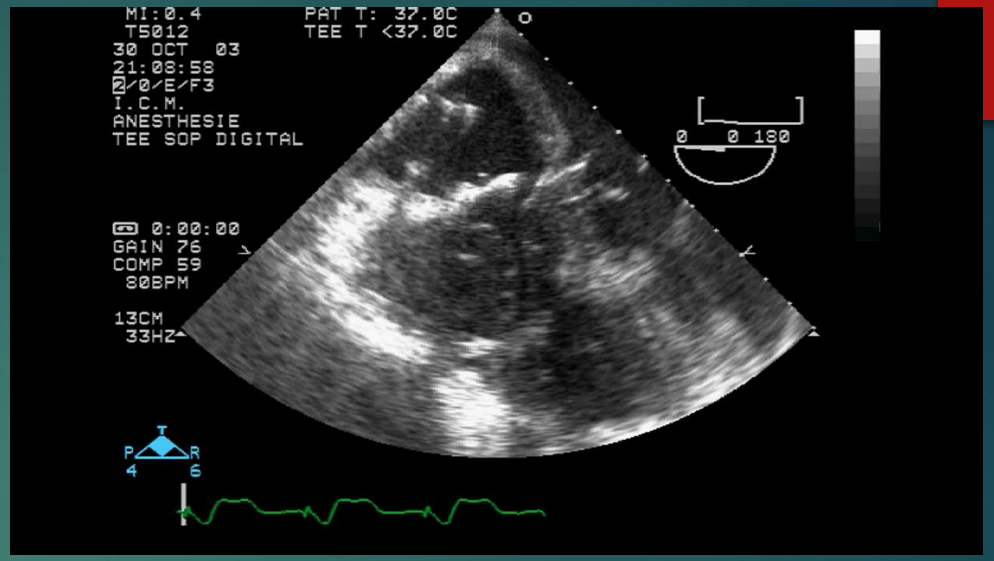
- Donc le Swan ne diminue pas la mortalité, mais le **saturomètre non plus!**
- Aucune évidence que le saturomètre influencerait le « outcome » anesthésique des patients
- **Le monitoring avec saturomètre en périopératoire est questionnable** en ce qui a trait au « outcomes, effectiveness, and efficiency »
- La prise de saturation continue n'a pas diminué la nombre de transferts aux SI, **ni la mortalité** et il n'est pas clair s'il y a un bénéfice réel à l'application de cette technologie chez les patients après une chirurgie cardiothoracique [⋯].

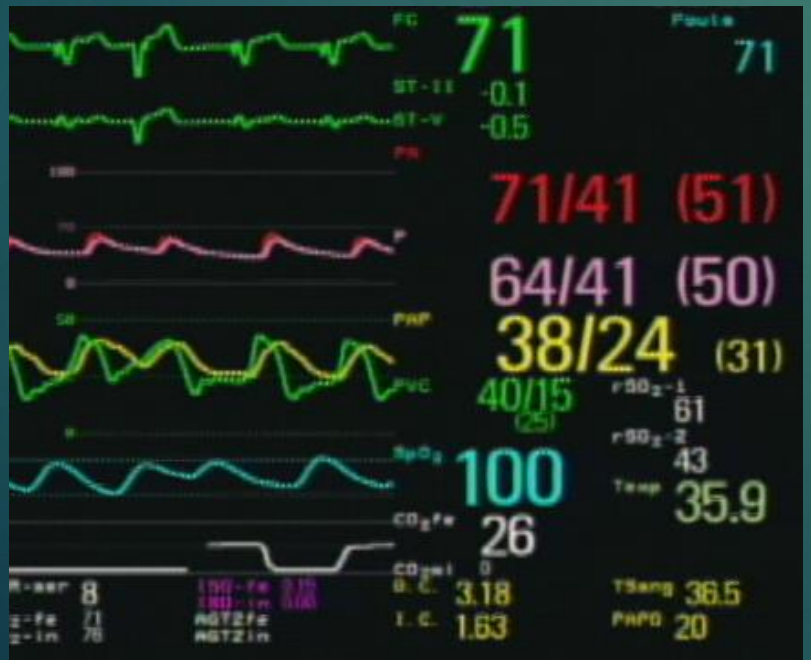
Indications

- Patient à haut risque
  - FEVG abaissée, dysfonction VD, HTAP, etc.
- Procédure chirurgicale complexe
- Contexte clinique : votre hôpital
  - Temps? Argent? Habileté technique? Capacité d'interprétation?

- Combiné à d'autres outils de monitoring!
  - Mesure de manière continue, « beat-to-beat »
  - Pratique et accessible aux SI avec plusieurs patients




MI:0.4
T5012
PAT T: 37.0C
TEE T <37.0C
30 OCT 03
21:08:58
2/0/E/F3
I.C.M.
ANESTHESIE
TEE SOP DIGITAL
0 0 180
0:00:00
GAIN 76
COMP 59
80BPM
13CM
33HZ
P 4
R 6


71
71
-0.1
-0.5
71/41 (51)
64/41 (50)
38/24 (31)
40/15 (25)
100
26
3.18
1.63
36.5
20


Masimo
97
74
15
13.4
1.0
20
4.0
18
36
0
0
0.0
16.0
13.0
67
30
30
65
-2
22
32
Radical-7
SedLine

Indications

- Monitoring CVP, PAP, Wedge, C.O., SVR et SVO2
  - Aider la prise en charge du choc
  - Estimer pression remplissage VG – ischémie myocardique, régurgitation/sténose mitrale, etc.
- Fonction VD systolique et diastolique, pressions remplissages VD reconnaissance et gestion HTAP, shunt/CIV, réponse aux traitements inhalés, etc.
- Pacing VD

- Courbe VD
  - Dysfonction diastolique VD
  - Couplage ventriculo-artériel
  - Obstruction CCVD

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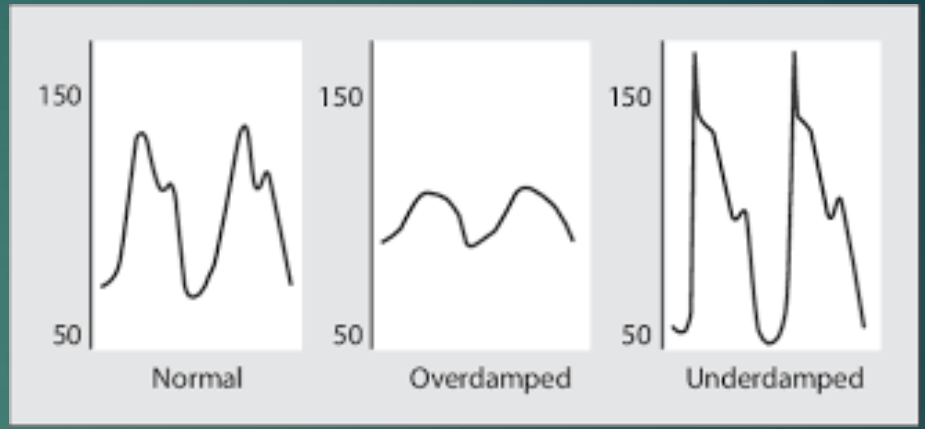
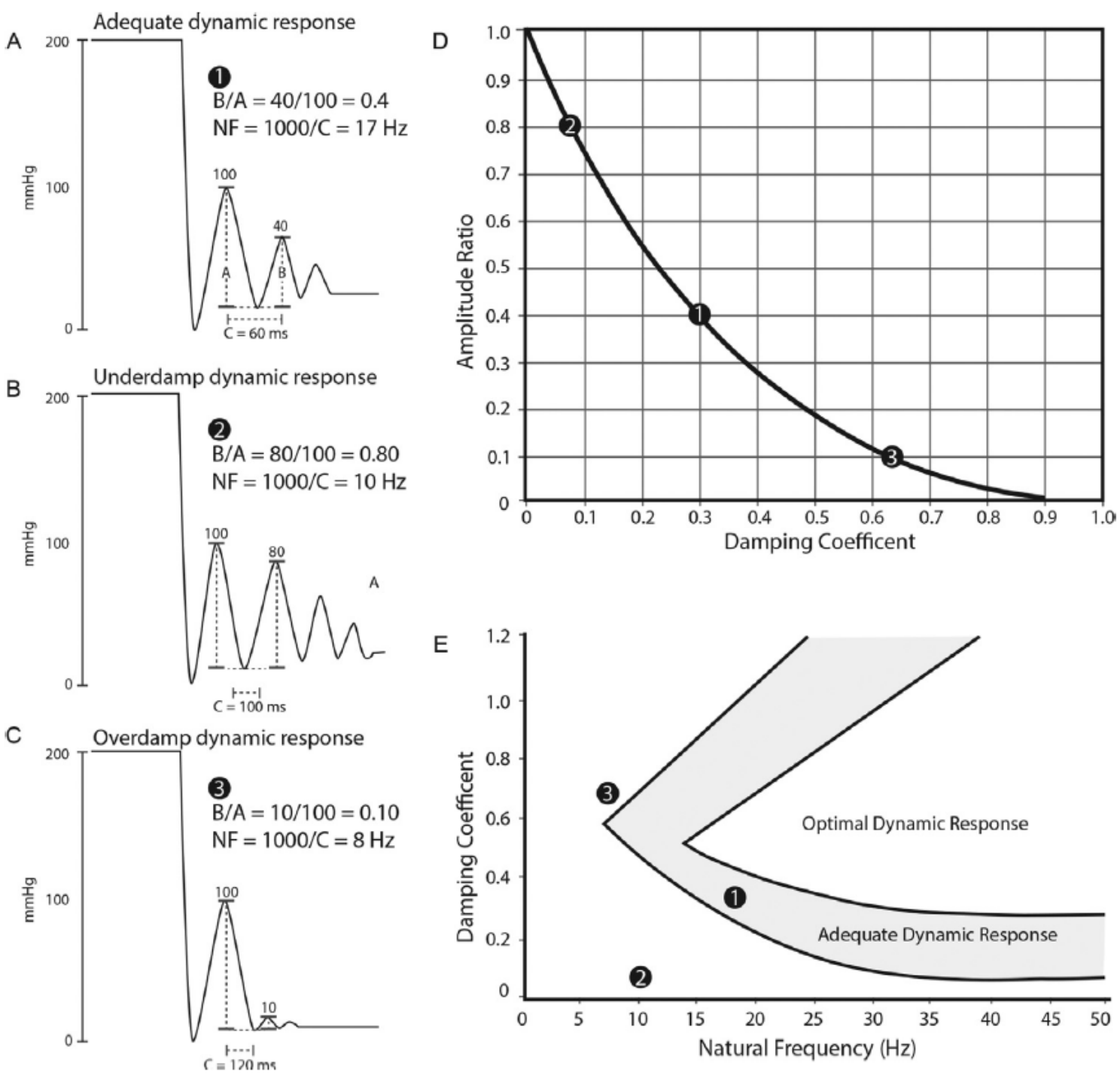
Analyse des courbes TVC-PAP-PVD

- Faire les zéros
- Évaluer la réponse dynamique
  - Flush test



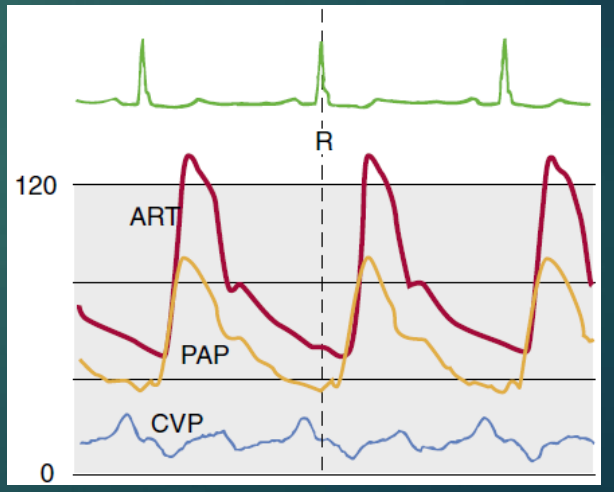

A
Adequate dynamic response
200
100
0
mmHg
1
B/A = 40/100 = 0.4
NF = 1000/C = 17 Hz
100
40
A
B
C = 60 ms
B
Underdamp dynamic response
2
B/A = 80/100 = 0.80
NF = 1000/C = 10 Hz
100
80
A
C = 100 ms
C
Overdamp dynamic response
3
B/A = 10/100 = 0.10
NF = 1000/C = 8 Hz
100
10
C = 120 ms
D
Amplitude Ratio
Damping Coefficent
E
Damping Coefficent
Optimal Dynamic Response
Adequate Dynamic Response
Natural Frequency (Hz)

Interprétation et limitations

- Interprétation : nous ne sommes pas très bons…
- Connaître les limitations d'un outil de monitoring pour l'utiliser sécuritairement
- Analyse et limitations
  - PAP
  - Débit cardiaque : ce qui influence les mesures
  - Pression de wedge : ce qui influence les mesures
  - Svo2 versus ScvO2
  - Ce qui est calculé versus mesuré
  - Analyse courbes TVC, PAP, PVD

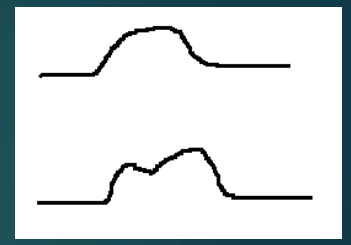
PAP

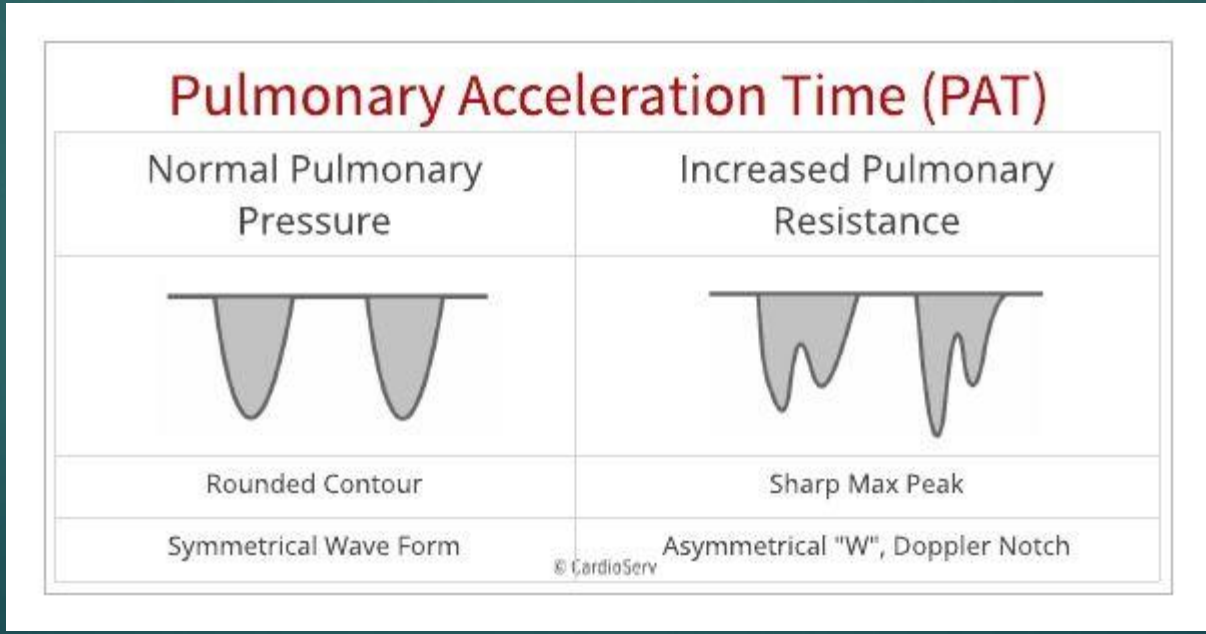
- Indique pression générée par VD – fonction VD
  - Augmente si ischémique/dysfonction VD de même que TVC
  - Diminue si défaillance sévère VD et incapable de générer pression
- Reflète pression remplissage gauche
- Analyse combinée à PVD



PAP

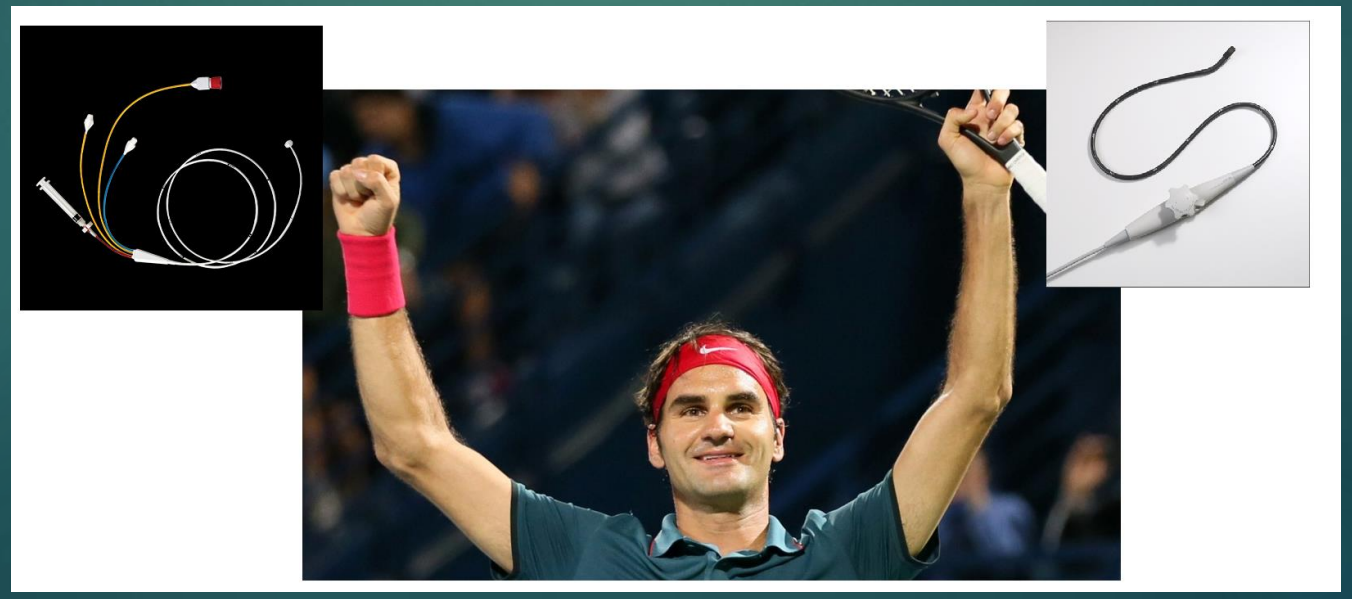
- Regarder « notch »
  - Augmentation des résistances pulmonaires crée une onde de réflexion dans l'AP. Cela crée un notch dans la courbe PAP
  - HTP thromboembolique chronique (CTEPH) : si notch proximal, veut dire que proximal, si distal veut dire que occlusion est distale et peut être difficile à aller chercher



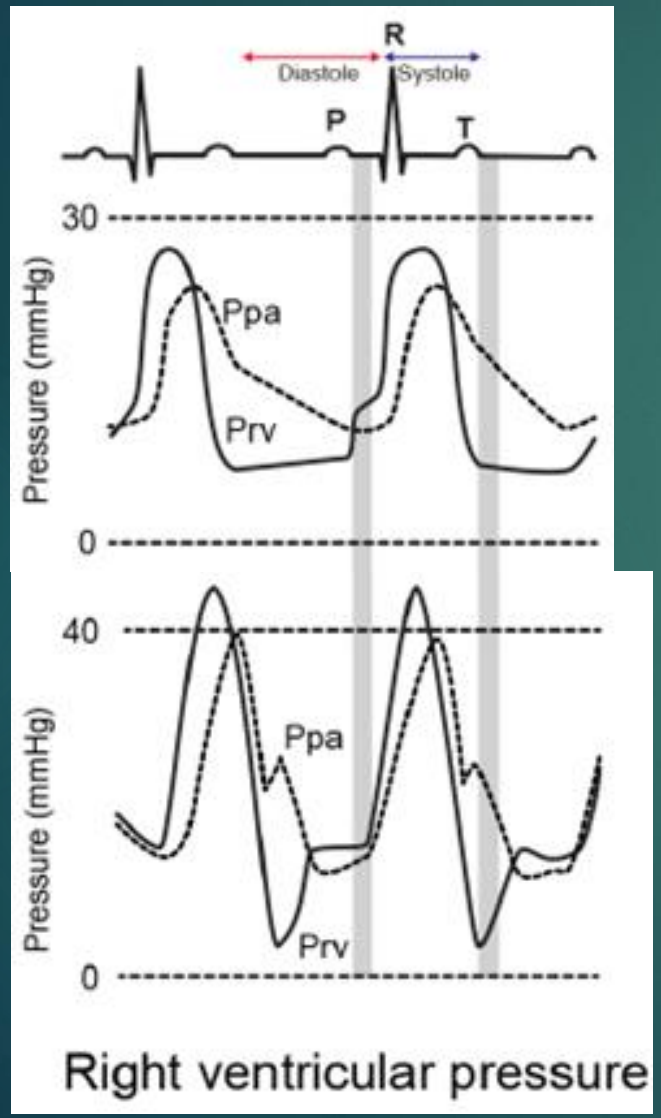


Swan + ETO : les 2 bras d'André Denault

- ETO mesures PAP via jet régurgitant valve tricuspide : 30-40% cas incapable de faire mesure
- Moniteur = *monere* = « to warn »
- ETO n'est pas un bon moniteur (pas d'alarme): mais permet de faire Dx!
- Mesure PAP gold standard = Swan



PAP + PVD



PAP N - VD N

PAP N - VD aN!

PAPm + TAM

- PAP > 60 mmHg
- PAPm > 30 mmHg
- PAPm ≥ 25% de la TAM

- Ratio normal TAM/PAPm environ 4 : exemple PAP 25 et TAs 100
- Lorsque ratio moins de 4 

Importance of Relative Pulmonary Hypertension in Cardiac Surgery: The Mean Systemic-to-Pulmonary Artery Pressure Ratio

Arnaud Robitaille, MD,* André Y. Denault, MD, FRCPC,* Pierre Couture, MD, FRCPC,*
Sylvain Bélisle, MD, FRCPC,* Annik Fortier, MSc,† Marie-Claude Guertin, PhD,† Michel Carrier, MD, FRCSC,‡
and Raymond Martineau, MD, FRCPC*

Table 3. Preoperative Hemodynamic Variables

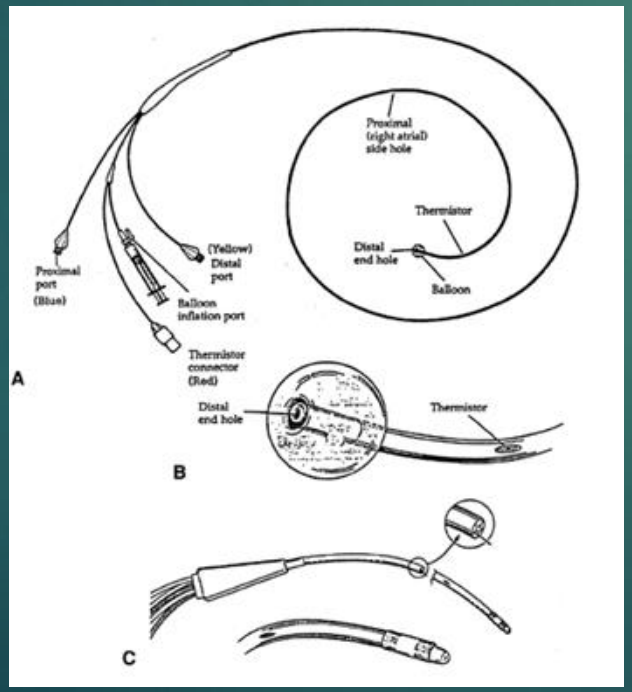
Variable	Total Population (n = 1,439)	No Complication (n = 1,137)	Hemodynamic Complications (n = 302)	*p* Value	Area Under ROC Curve (Lower CI; Upper CI)
PCWP (mmHg)	14 ± 6	13 ± 5	16 ± 7	<0.0001	0.59 (0.54; 0.63)
CVP (mmHg)	10 ± 4	10 ± 4	12 ± 5	<0.0001	0.59 (0.56; 0.63)
HR (beats/min)	61 ± 13	60 ± 12	63 ± 15	0.0022	0.54 (0.51; 0.58)
SAP (mmHg)	112 ± 18	113 ± 18	109 ± 19	0.0044	0.55 (0.51; 0.59)
DAP (mmHg)	55 ± 11	56 ± 11	53 ± 11	<0.0001	0.58 (0.55; 0.62)
MAP (mmHg)	74 ± 12	75 ± 11	72 ± 12	<0.0001	0.55 (0.51; 0.59)
SPAP (mmHg)	31 ± 10	30 ± 9	36 ± 13	<0.0001	0.66 (0.63; 0.70)
DPAP (mmHg)	16 ± 6	16 ± 6	19 ± 8	<0.0001	0.62 (0.59; 0.66)
MPAP (mmHg)	21 ± 7	20 ± 6	25 ± 9	<0.0001	0.64 (0.61; 0.68)
Cardiac index (L/min/m^2)	2.2 ± 0.6	2.2 ± 0.6	2.1 ± 0.6	0.0009	0.59 (0.55; 0.62)
SVRI (dynes · sec · cm^{-5}/m^2)	2,449 ± 717	2,444 ± 692	2,470 ± 806	0.6153	0.50 (0.46; 0.54)
PVRI (dynes · sec · cm^{-5}/m^2)	293 ± 187	275 ± 169	360 ± 231	<0.0001	0.61 (0.57; 0.65)
SI (mL/m^2)	37 ± 9	38 ± 9	34 ± 10	<0.0001	0.62 (0.58; 0.66)
LVSWI (g/m/m^2)	30 ± 10	32 ± 10	26 ± 10	<0.0001	0.66 (0.63; 0.70)
RVSWI (g/m/m^2)	5.3 ± 2.8	5.2 ± 2.7	5.8 ± 3.3	0.0030	0.55 (0.52; 0.59)
MAP/MPAP	3.9 ± 1.4	4.0 ± 1.4	3.3 ± 1.3	<0.0001	0.67 (0.63; 0.70)
SVRI/PVRI*	9 (1, 246)	10 (2, 246)	8 (1, 94)	<0.0001	0.62 (0.58; 0.66)
LVSWI/RVSWI*	6.1 (0.6, 64.0)	6.4 (0.9, 64.0)	5.1 (0.6, 28.8)	<0.0001	0.64 (0.60; 0.68)
MPAP-PCWP (mmHg)	7 ± 4	7 ± 4	9 ± 5	<0.0001	0.59 (0.55; 0.63)

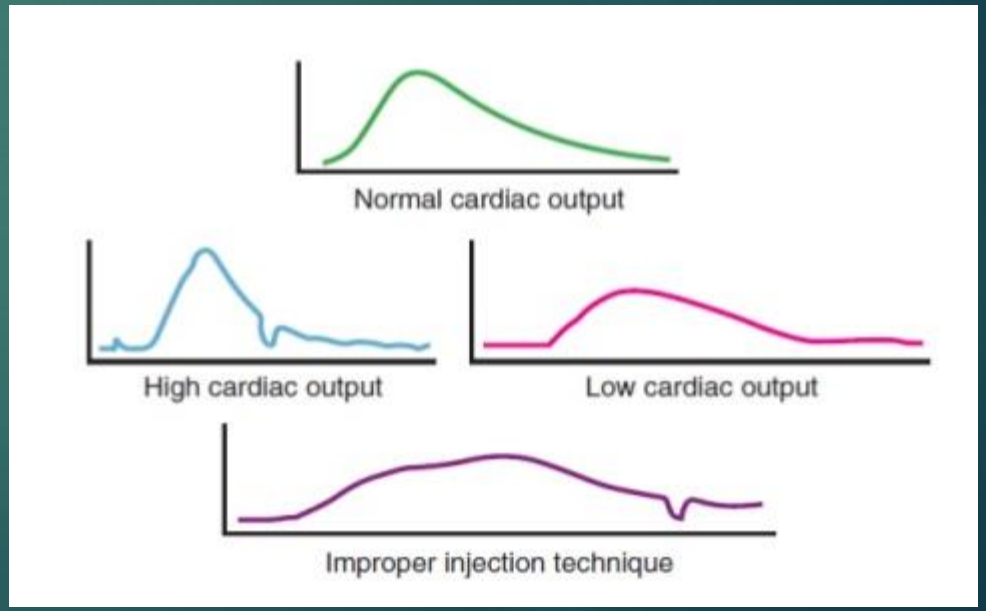
Abbreviations: ROC, receiver-operating characteristic; CI, confidence interval; PCWP, pulmonary capillary wedge pressure; CVP, central venous pressure; HR, heart rate; SAP, systolic arterial pressure; DAP, diastolic arterial pressure; MAP, mean arterial pressure; SPAP, systolic pulmonary arterial pressure; DPAP, diastolic pulmonary arterial pressure; MPAP, mean pulmonary arterial pressure; SVRI, systemic vascular resistance index; PVRI, pulmonary vascular resistance index; SI, stroke index; LVSWI, left ventricular stroke work index; RVSWI, right ventricular stroke work index.

*Variables are given as mean ± SD, except for SVRI/PVRI and LVSWI/RVSWI, whose distributions were skewed, and are given as median (min, max).

Débit cardiaque

- Débit cardiaque par thermodilution : « Gold Standard »
- Liquide température pièce (10 ml seringue standardisée système stérile fermé)
- Faire 3 mesures pour ↓ influence cycle respiratoire (moyenne des trois)
- Faire mesures rapprochées (même statut hémodynamique) par la même personne





Débit cardiaque

- Normal : 4-6,5 L/min
- Erreurs :
  - Injecta moins de 10 ml
  - Prendre une seule mesure

Box 40-7 Factors Influencing the Accuracy of Thermodilution Cardiac Output Measurement

Intracardiac shunts

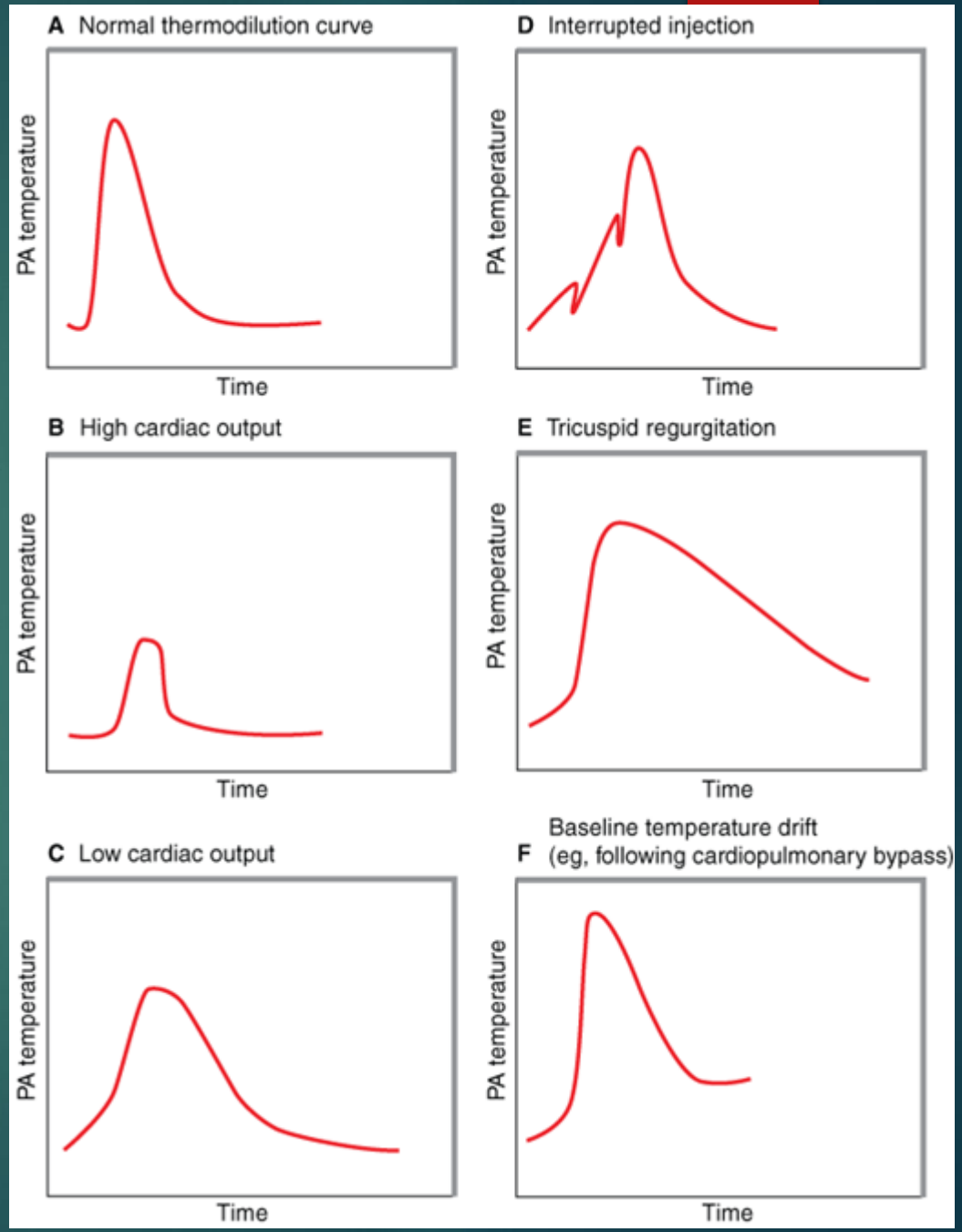
Tricuspid or pulmonic valve regurgitation

Inadequate delivery of thermal indicator
- Central venous injection site within the catheter introducer sheath
- Warming of iced injectate

Thermistor malfunction from fibrin or a clot

Pulmonary artery blood temperature fluctuations
- Post–cardiopulmonary bypass status
- Rapid intravenous fluid administration

Respiratory cycle influences

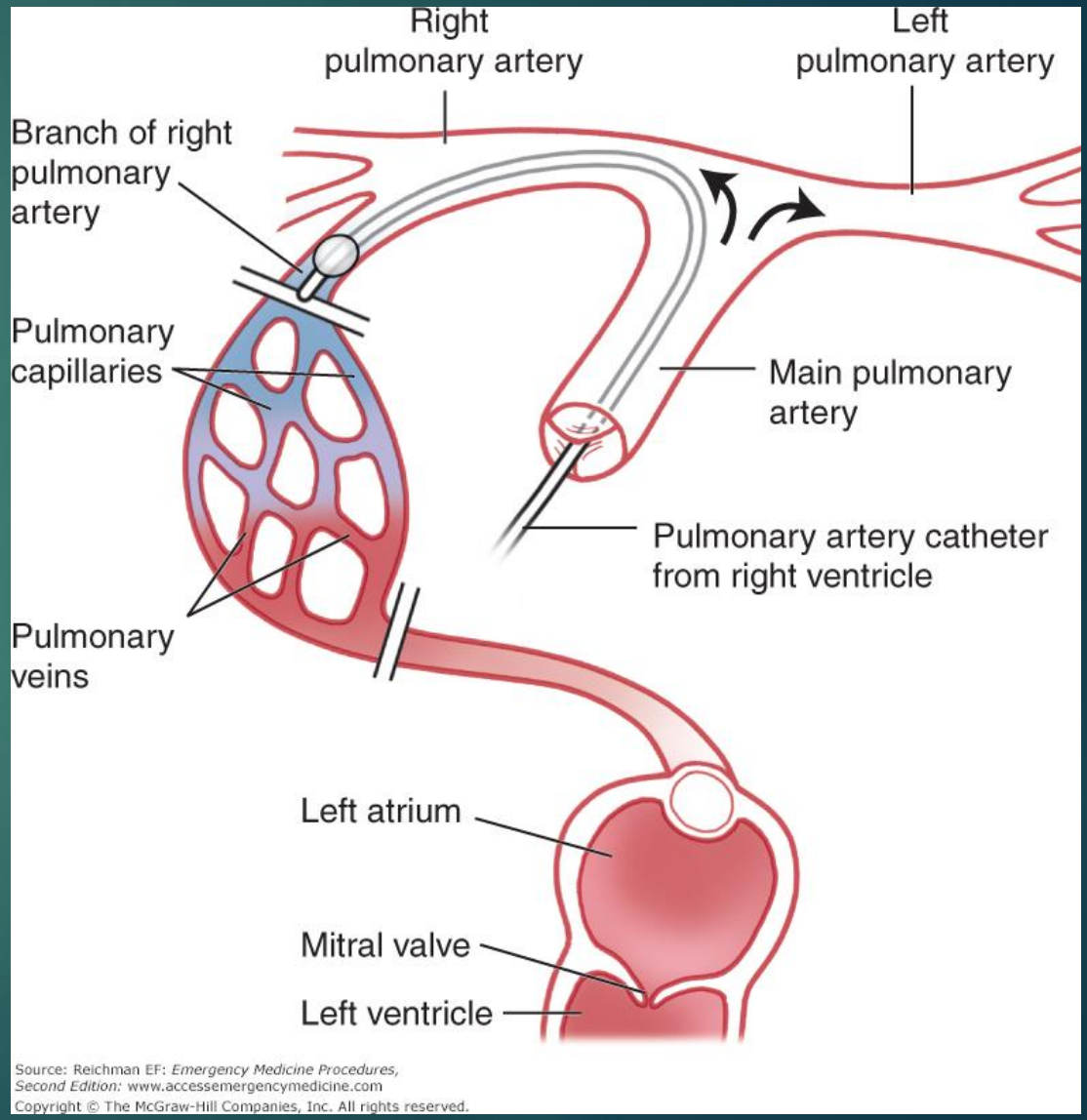


Débit cardiaque

- Débit cardiaque optimal difficile à définir
- Débit optimal change d'un patient à l'autre et chez un même patient selon son état clinique
- Mesure du debit difficile à obtenir de manière fiable
- Débit cardiaque souvent < 2L/min/m2 post CEC : dilatation chambres cardiaques droites? Patients âgés non inclus dans les calculs de normalité?
- Observer la tendance plutôt que le chiffre isolé

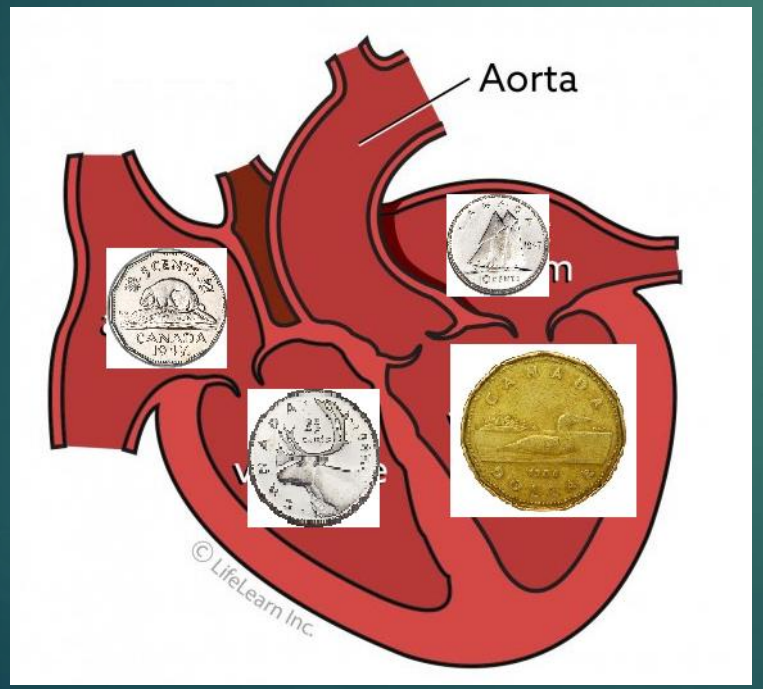
Wedge

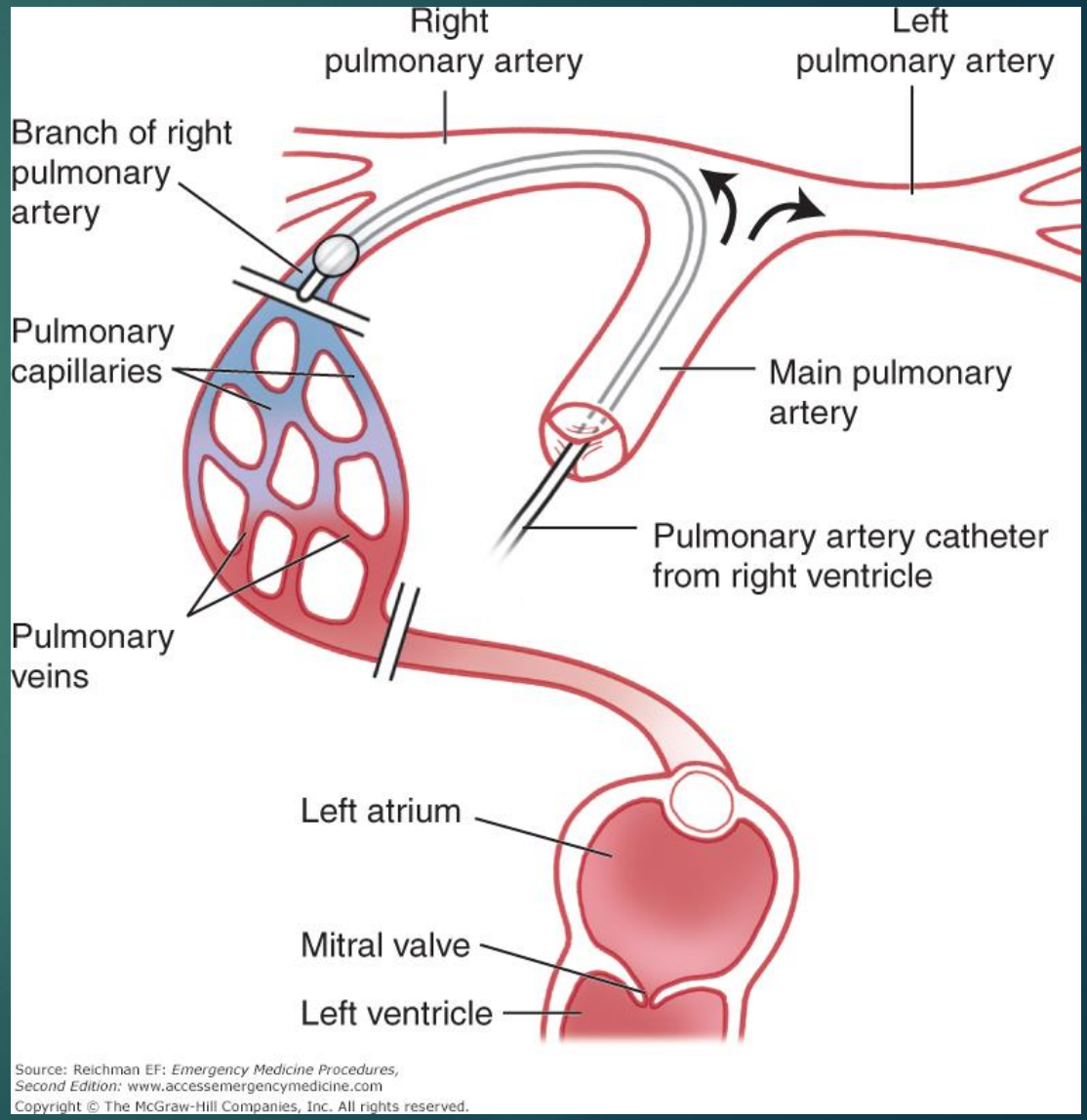
- Pression transmise de l'OG
- Évaluer les pressions remplissage VG
- Indice de volémie? NON
- Valeurs N : ~10 mmHg (6-12 mmHg)



Wedge

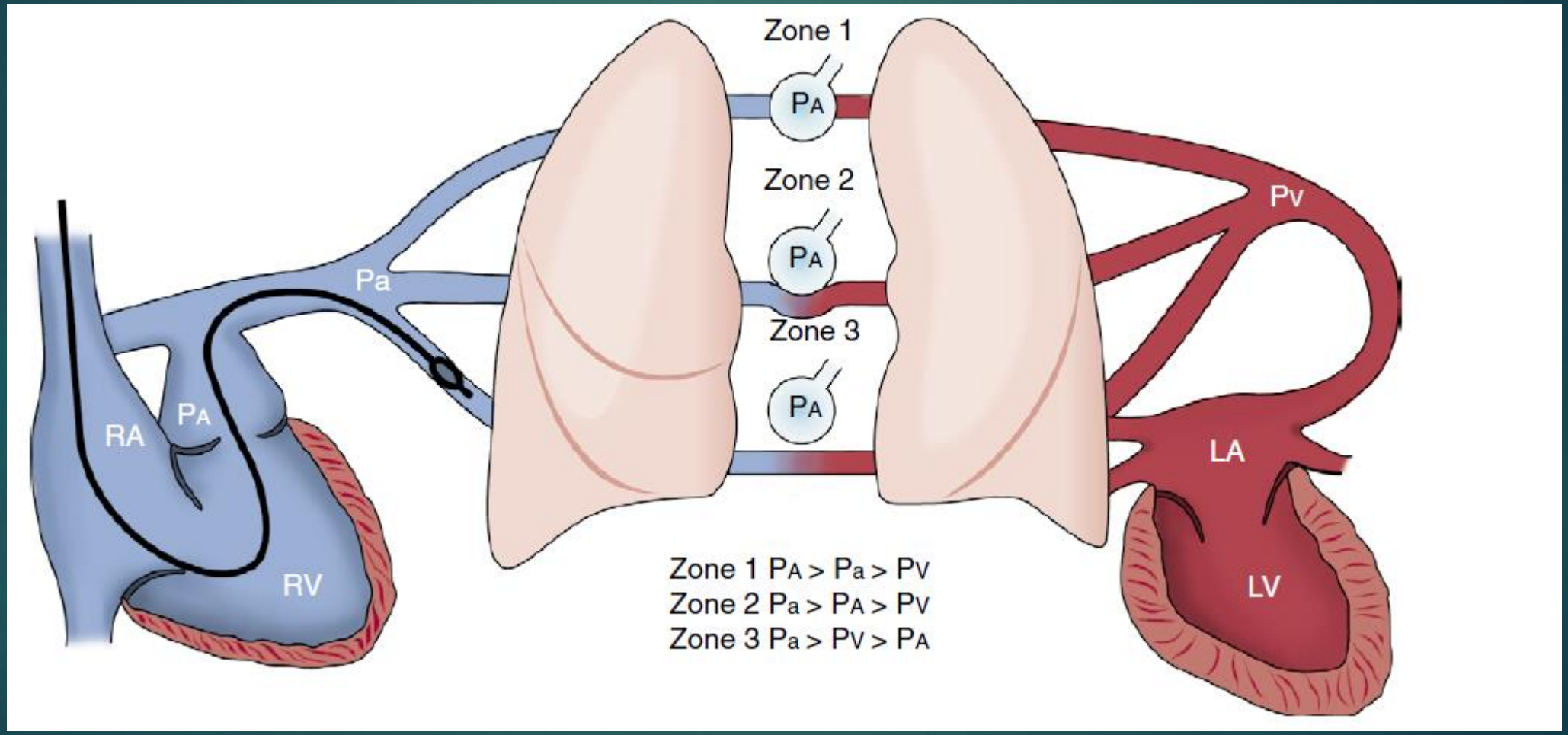
- Pression transmise de l'OG
- Évaluer les pressions remplissage VG
- Valeurs N : ~10 mmHg (6-12 mmHg)





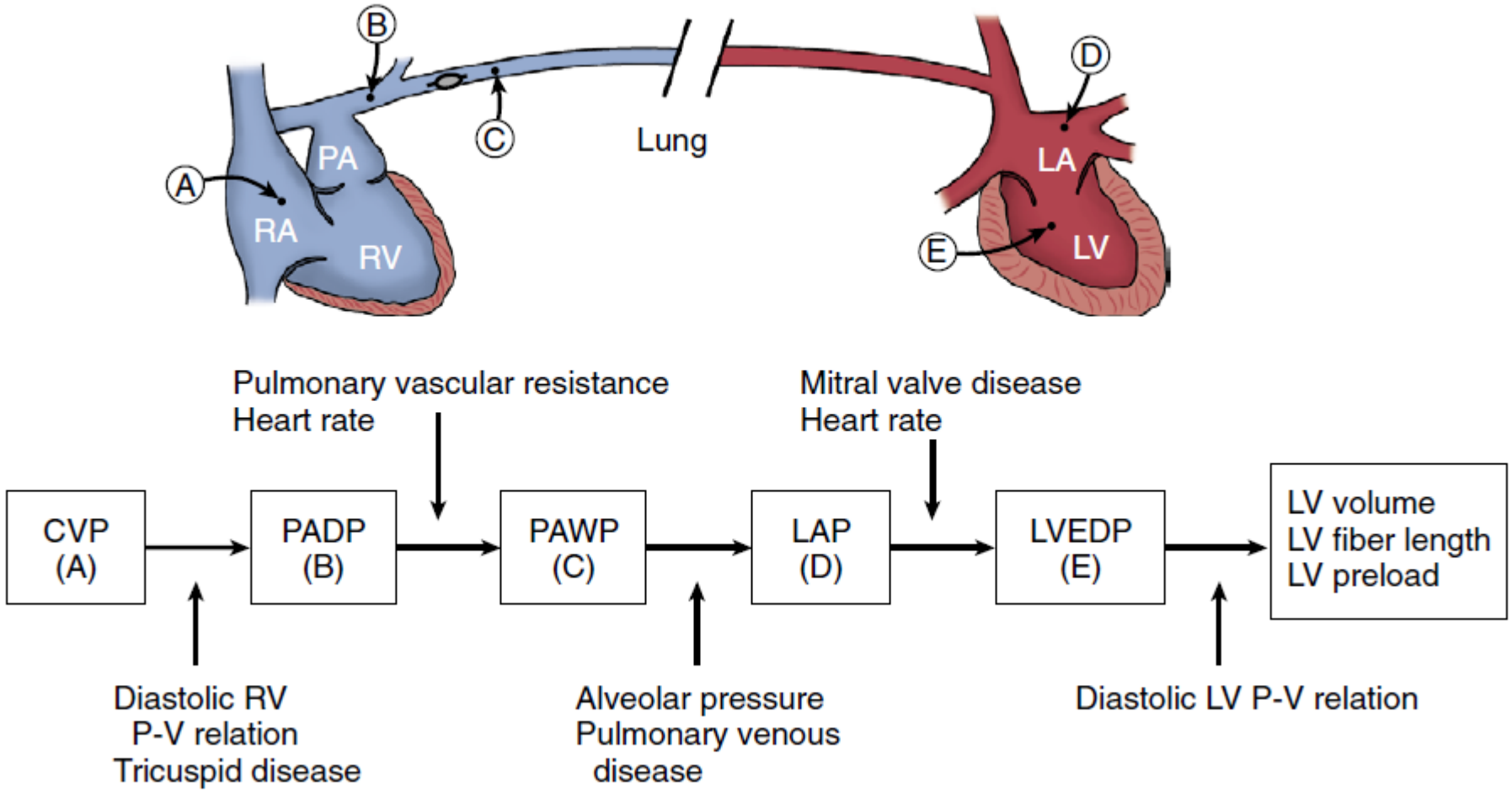
Wedge : doit être zone 3

Zone 1 et 2 influencées pression alvéolaire



Position couchée favorise entrée cathéter zone 3

Wedge


B
C
Lung
D
A
PA
LA
RA
RV
LV
E
Pulmonary vascular resistance
Heart rate
Mitral valve disease
Heart rate
CVP
(A)
PADP
(B)
PAWP
(C)
LAP
(D)
LVEDP
(E)
LV volume
LV fiber length
LV preload
Diastolic RV
P-V relation
Tricuspid disease
Alveolar pressure
Pulmonary venous
disease
Diastolic LV P-V relation

↑ Wedge ↓

Wedge PTDVG

Table 40-5 Underestimation of Left Ventricular End-Diastolic Pressure

Condition	Site of Discrepancy	Cause of Discrepancy
Diastolic dysfunction	Mean LAP < LVEDP	Increased end-diastolic a wave
Aortic regurgitation	LAP a wave < LVEDP	Mitral valve closure before end-diastole
Pulmonic regurgitation	PADP < LVEDP	Bidirectional runoff for pulmonary artery flow
Right bundle branch block	PADP < LVEDP	Delayed pulmonic valve opening
After pneumonectomy	PAWP < LAP or LVEDP	Obstruction of pulmonary blood flow

Wedge N/PTDVG

Wedge PTDVG

Table 40-6 Overestimation of Left Ventricular End-Diastolic Pressure

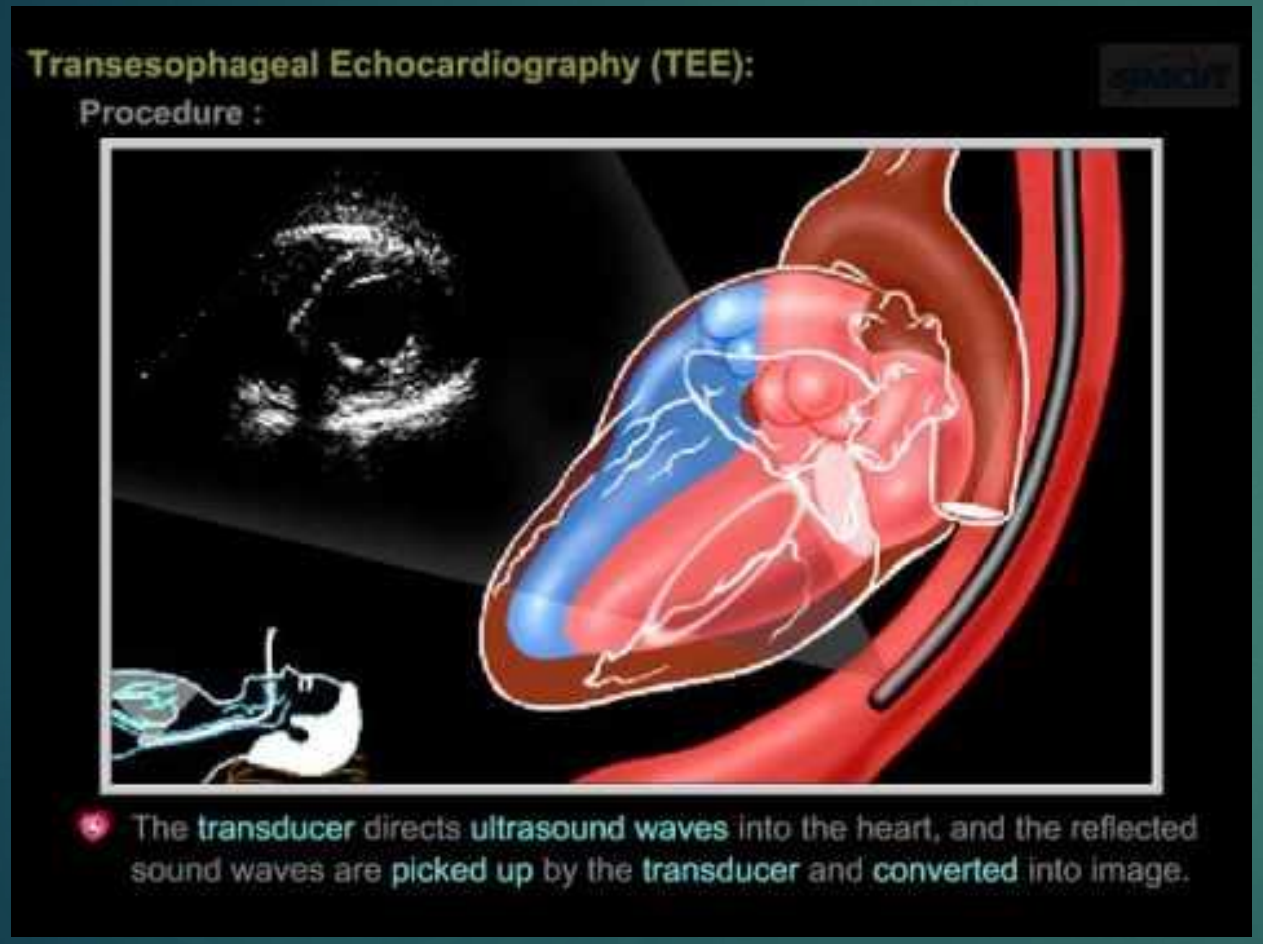
Condition	Site of Discrepancy	Cause of Discrepancy
Positive end-expiratory pressure	Mean PAWP > mean LAP	Creation of lung zone 1 or 2 or pericardial pressure changes
Pulmonary arterial hypertension	PADP > mean PAWP	Increased pulmonary vascular resistance
Pulmonary veno-occlusive disease	Mean PAWP > mean LAP	Obstruction to flow in large pulmonary veins
Mitral stenosis	Mean LAP > LVEDP	Obstruction to flow across the mitral valve
Mitral regurgitation	Mean LAP > LVEDP	Retrograde systolic v wave raises mean atrial pressure
Ventricular septal defect	Mean LAP > LVEDP	Antegrade systolic v wave raises mean atrial pressure
Tachycardia	PADP > mean LAP > LVEDP	Short diastole creates pulmonary vascular and mitral valve gradients

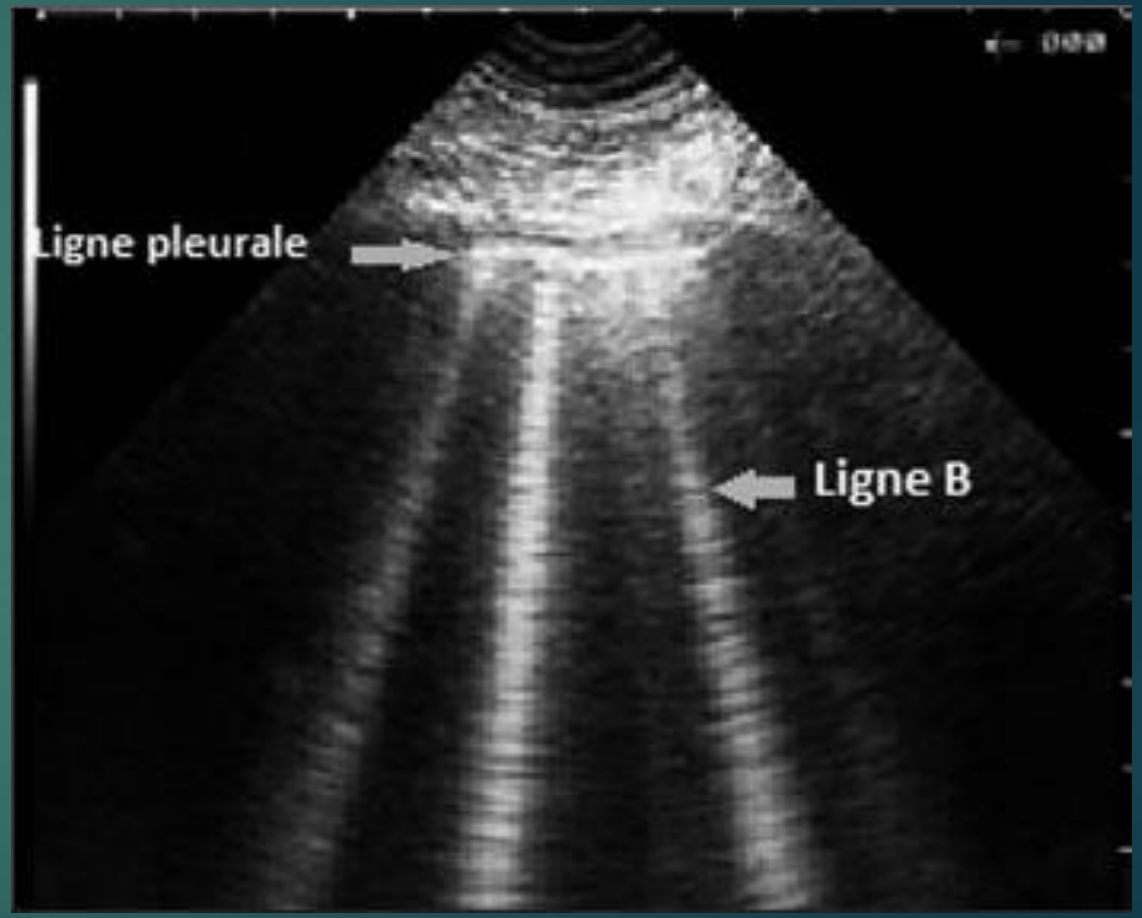
Mais pourquoi veut-on connaître la vrai valeur de la PTDVG/Wedge?

Pourquoi parle-t-on encore du wedge…

- Diagnostiquer une dysfonction VG
- Évaluer si présence d'œdème pulmonaire
- Faire un diagnostic d'insuffisance mitrale ou de sténose mitrale
- Faire un diagnostic d'insuffisance aortique
- Etc.

ETO et écho pulmonaire





Wedge

- La plupart des anesthésiologistes n'utilisent plus le wedge
- Avec ETO en SOP beaucoup plus facile d'évaluer les pressions de remplissage G et surtout de trouver la cause!

SvO2 : saturation veineuse mixte

$$S\bar{v}O_2 = SaO_2 - \frac{\dot{V}O_2}{\dot{Q} \times 1.36 \times Hb}$$

where $S\bar{v}O_2$ = mixed venous hemoglobin saturation (%)
SaO_2 = arterial hemoglobin saturation (%)
$\dot{V}O_2$ = oxygen consumption (mL O_2/min)
$\dot{Q}$ = cardiac output (L/min)
Hb = hemoglobin concentration (g/dL)

Valeur normale ≥ 65-70%

$DO_2 = CaO_2 \cdot DC$ où DC: débit cardiaque
CaO_2: contenu artériel en oxygène
$CaO_2 = [(1.34 \cdot Hb) \cdot SaO_2] + (0.0031 \cdot PaO_2)$

Livraison O2

$VO_2 = (CaO_2 - CvO_2) \cdot DC$ où CvO_2 : contenu en O_2 du sang veineux mêlé

Donc:
$VO_2 = (1.34 \cdot Hb) \cdot (SaO_2 - SvO_2) \cdot DC$
valeur normale: 3.5 mL/kg/min ou 250 mL/min
valeur normale SvO_2: 70%

Consommation O2

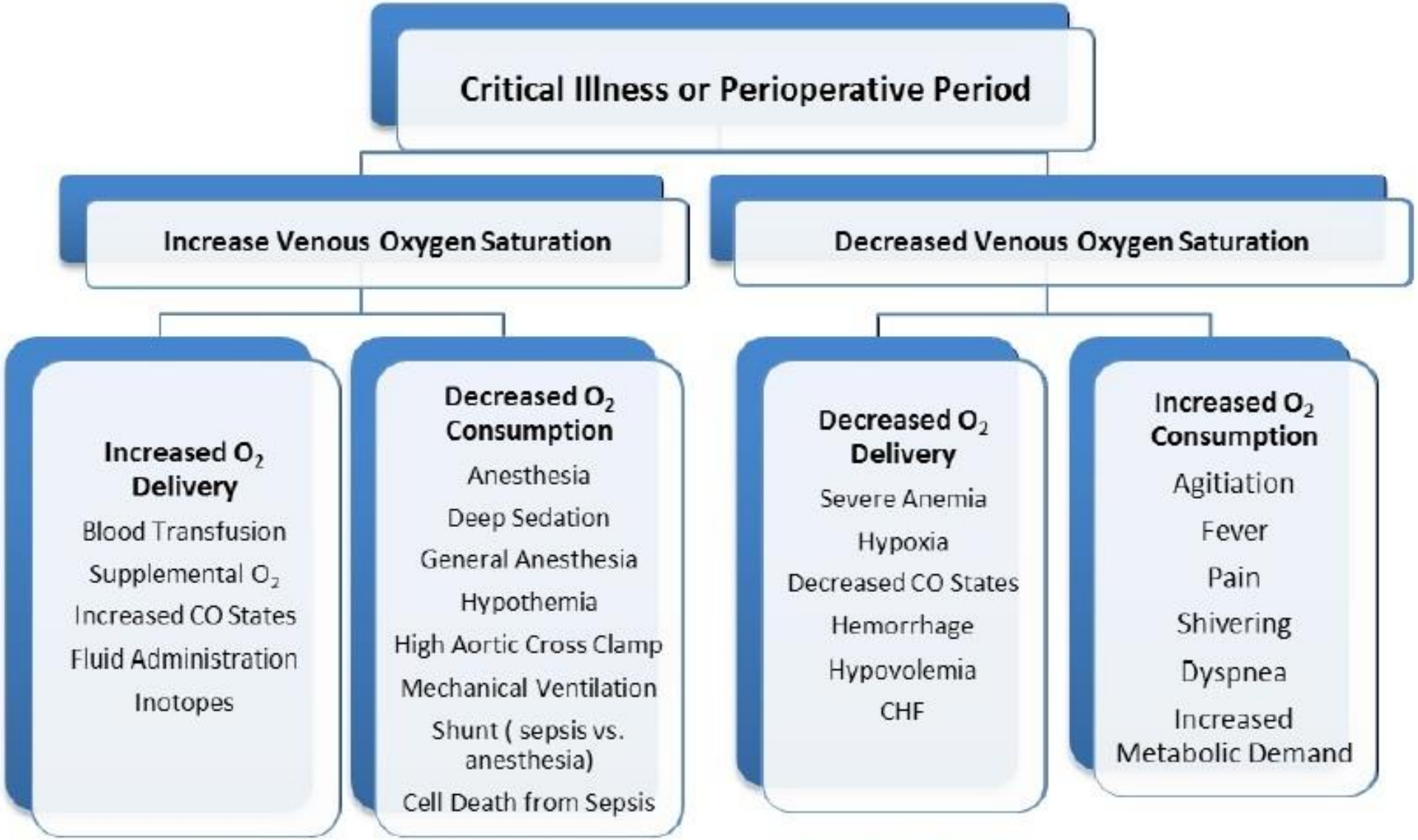


Table 2: Changes leading to alteration in venous saturation in the critically ill.

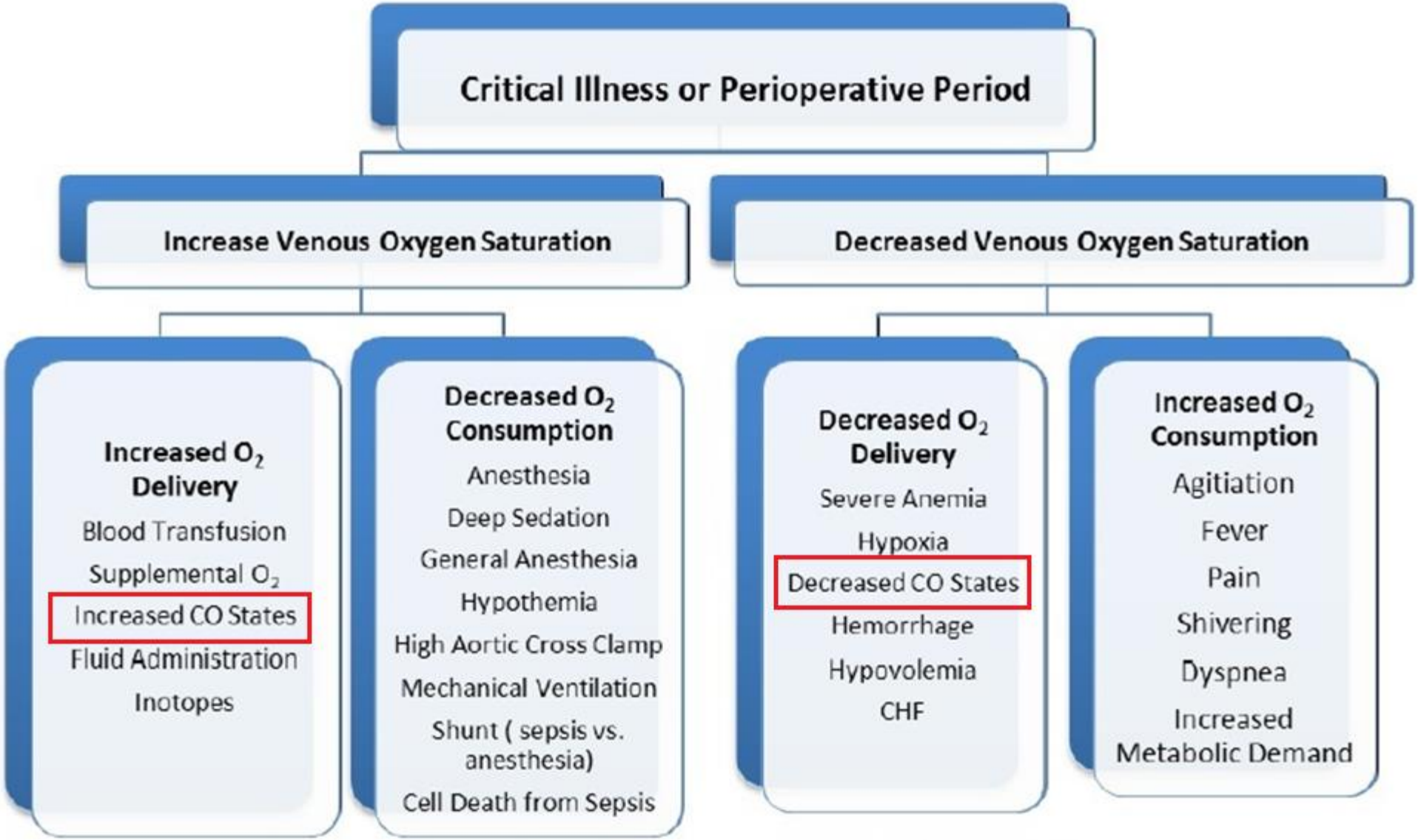
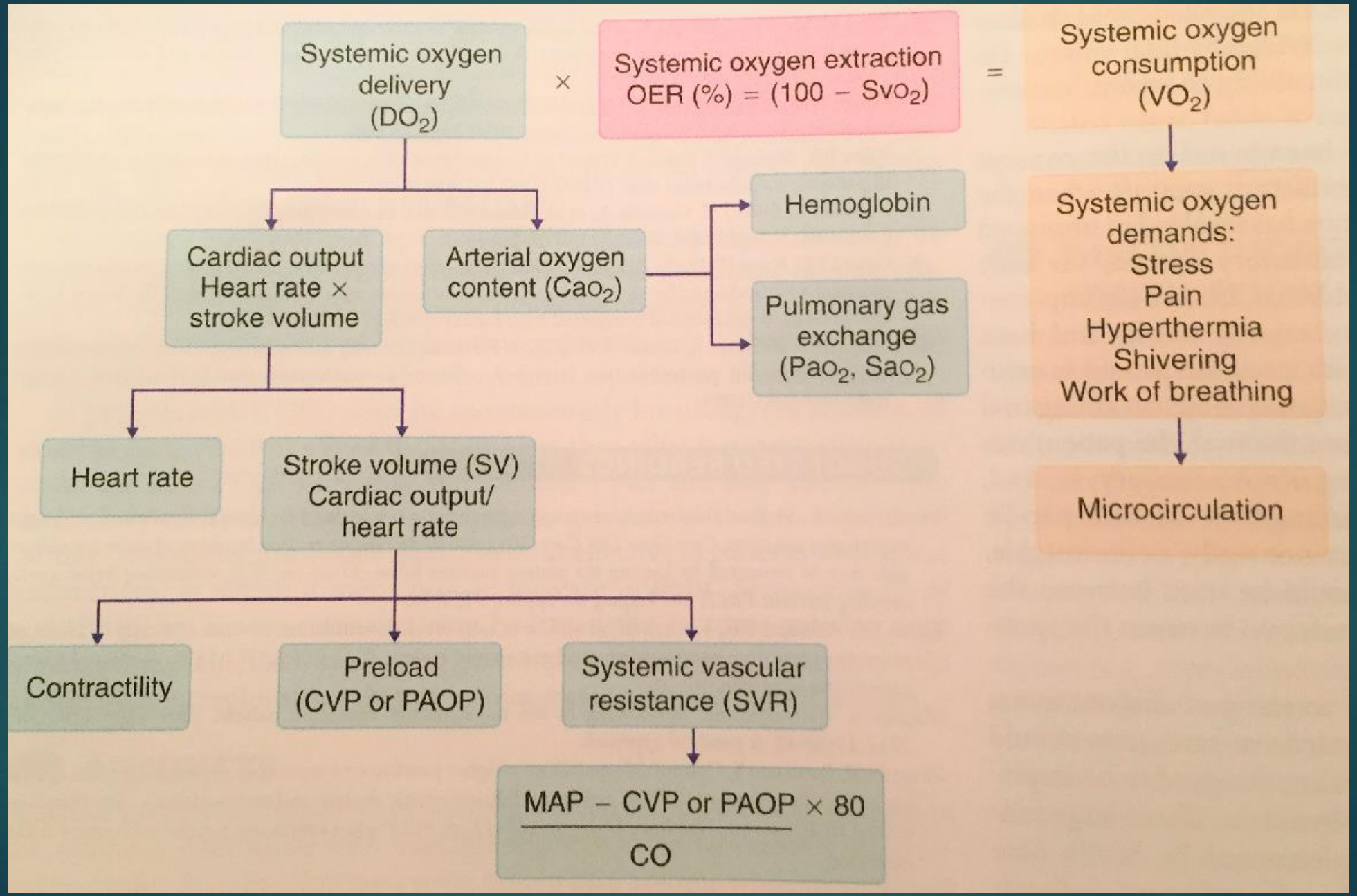


Table 2: Changes leading to alteration in venous saturation in the critically ill.


Systemic oxygen delivery (DO_2)
×
Systemic oxygen extraction OER (%) = (100 − Svo_2)
=
Systemic oxygen consumption (VO_2)
Cardiac output Heart rate × stroke volume
Arterial oxygen content (Cao_2)
Hemoglobin
Pulmonary gas exchange (Pao_2, Sao_2)
Systemic oxygen demands: Stress Pain Hyperthermia Shivering Work of breathing
Heart rate
Stroke volume (SV) Cardiac output/ heart rate
Microcirculation
Contractility
Preload (CVP or PAOP)
Systemic vascular resistance (SVR)
MAP − CVP or PAOP × 80 / CO

SvO2 versus ScvO2 (Saturation VCS)

- SvO2 : reflète tout le corps (MS, MI, abdo, tête, Coeur)
- ScvO2 : mesurée VCS → reflète MS + tête
- ScvO2 plus haute que SvO2 sauf si shunt (Sat veineuse sinus coroniare 30%)
- Évaluation des shunts CIA-CIV résiduels post fermeture
- ScvO2 moins fiable mais corrélée avec l'adéquation du débit cardiaque

Prise en charge du choc

Prise en charge du choc

The NEW ENGLAND JOURNAL of MEDICINE

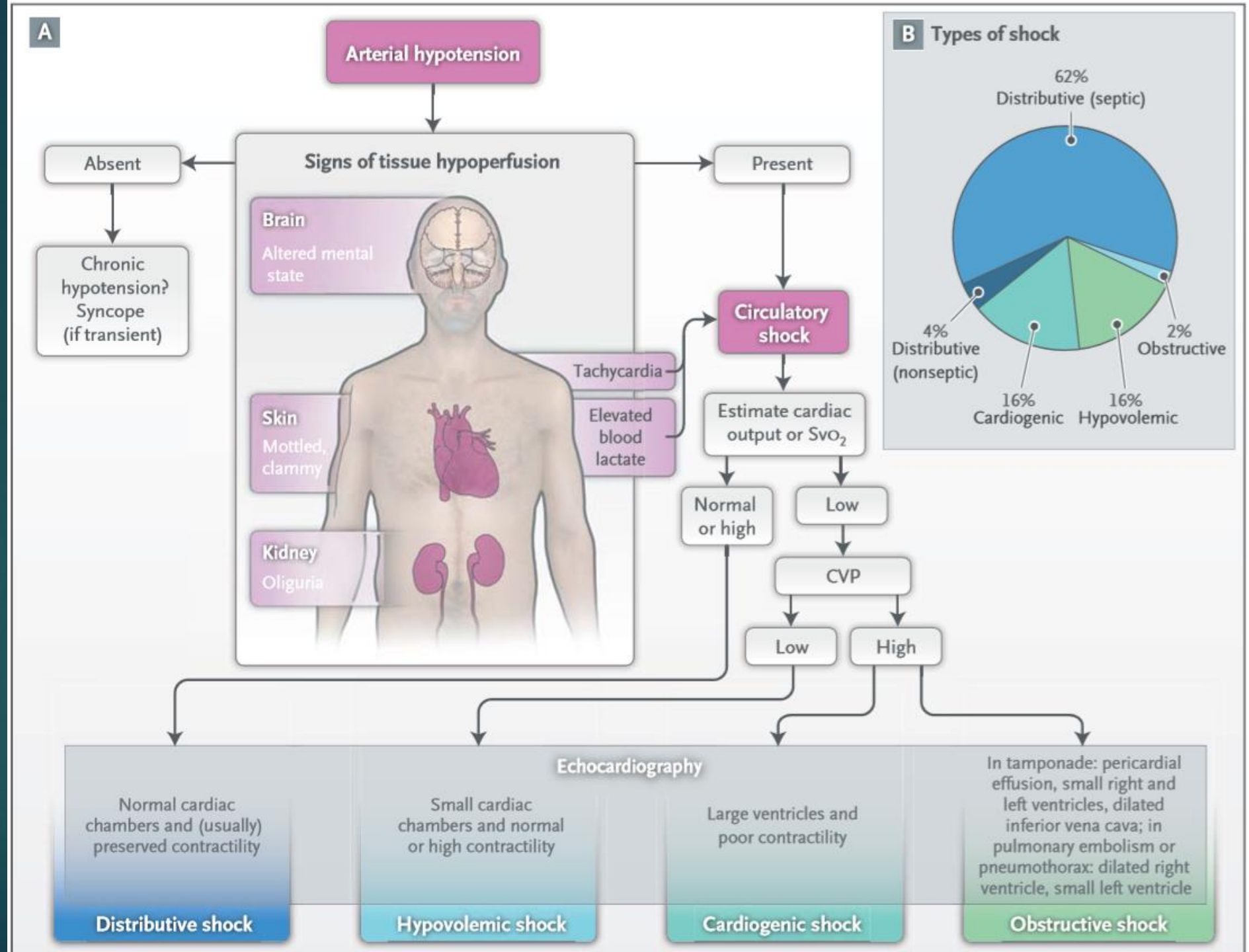
REVIEW ARTICLE

CRITICAL CARE MEDICINE

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

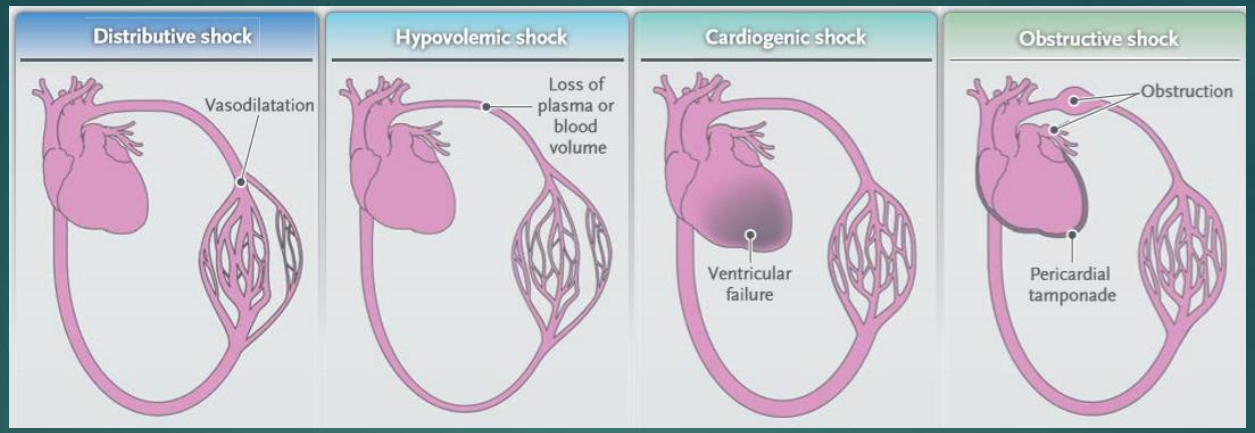
Circulatory Shock

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

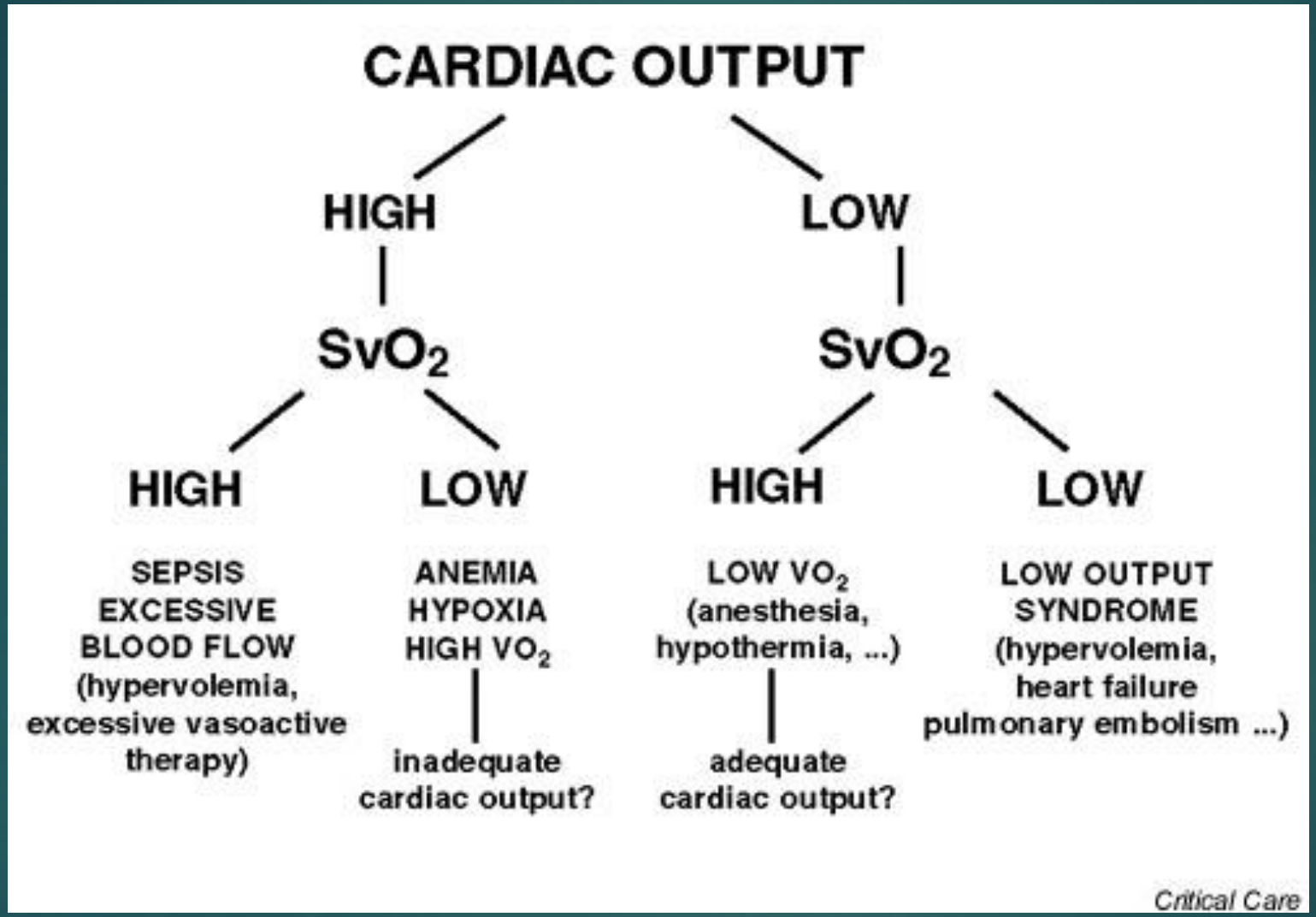

A
Arterial hypotension
Absent
Chronic hypotension? Syncope (if transient)
Signs of tissue hypoperfusion
Brain
Altered mental state
Skin
Mottled, clammy
Kidney
Oliguria
Tachycardia
Elevated blood lactate
Present
Circulatory shock
Estimate cardiac output or SvO_2
Normal or high
Low
CVP
Low
High
B Types of shock
62%
Distributive (septic)
4%
Distributive (nonseptic)
16%
Cardiogenic
16%
Hypovolemic
2%
Obstructive
Echocardiography
Normal cardiac chambers and (usually) preserved contractility
Distributive shock
Small cardiac chambers and normal or high contractility
Hypovolemic shock
Large ventricles and poor contractility
Cardiogenic shock
In tamponade: pericardial effusion, small right and left ventricles, dilated inferior vena cava; in pulmonary embolism or pneumothorax: dilated right ventricle, small left ventricle
Obstructive shock

CHOC

- Choc mixte!
- 50% des cas de de choc septique ont aussi choc cardiogénique

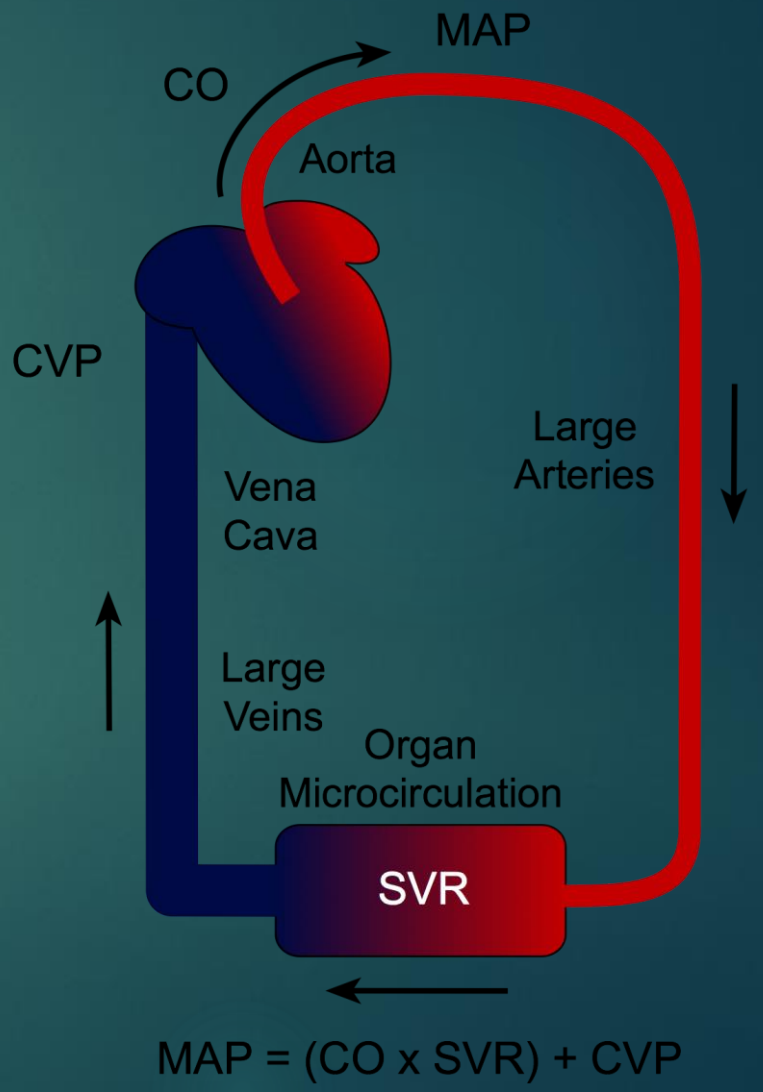


Type de choc	CVP/PAP	Wedge	SVR	CO	SvO2	Exemple clinique
Hypovolémique	↓	↓	↑	↓	↓	Hémorragie, « leak » capillaire
Cardiogénique	↑	↑	↑	↓	↓	Infarctus myocarde, arythmie
Obstructif	↑	↑ →	↑ →	↓	↓	Embolie pulmonaire, pneumothorax sous tension
Distributif	↓	↓	↓	↑ (→)	↑	Anaphylaxie, Sepsis, choc neurogénique


CARDIAC OUTPUT
HIGH
LOW
SvO2
SvO2
HIGH
LOW
HIGH
LOW
SEPSIS
EXCESSIVE
BLOOD FLOW
(hypervolemia,
excessive vasoactive
therapy)
ANEMIA
HYPOXIA
HIGH VO2
inadequate
cardiac output?
LOW VO2
(anesthesia,
hypothermia, ...)
adequate
cardiac output?
LOW OUTPUT
SYNDROME
(hypervolemia,
heart failure
pulmonary embolism ...)
Critical Care

Calculé vs mesuré

- Valeurs mesurées : D.C., TVC, PAP, Wedge
- Valeur souvent estimée : wedge → PAP diastolique
- Valeur calculée : RVS
- Algorithme complexe mais basé sur formule



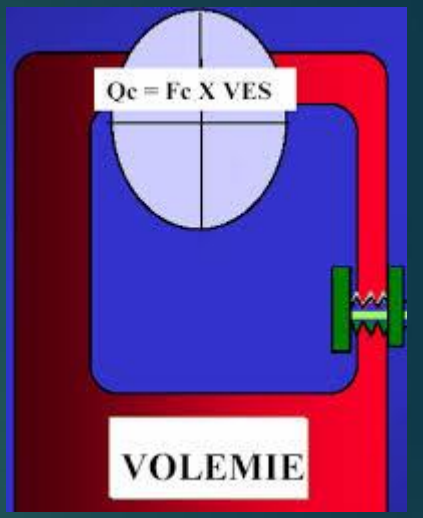
TVC

Box 40-4 Indications for Central Venous Cannulation

- Central venous pressure monitoring
- Pulmonary artery catheterization and monitoring
- Transvenous cardiac pacing
- Temporary hemodialysis
- Drug administration
  - Concentrated vasoactive drugs
  - Hyperalimentation
  - Chemotherapy
  - Agents irritating to peripheral veins
  - Prolonged antibiotic therapy (e.g., endocarditis)
- Rapid infusion of fluids (via large cannulas)
  - Trauma
  - Major surgery
- Aspiration of air emboli
- Inadequate peripheral intravenous access
- Sampling site for repeated blood testing

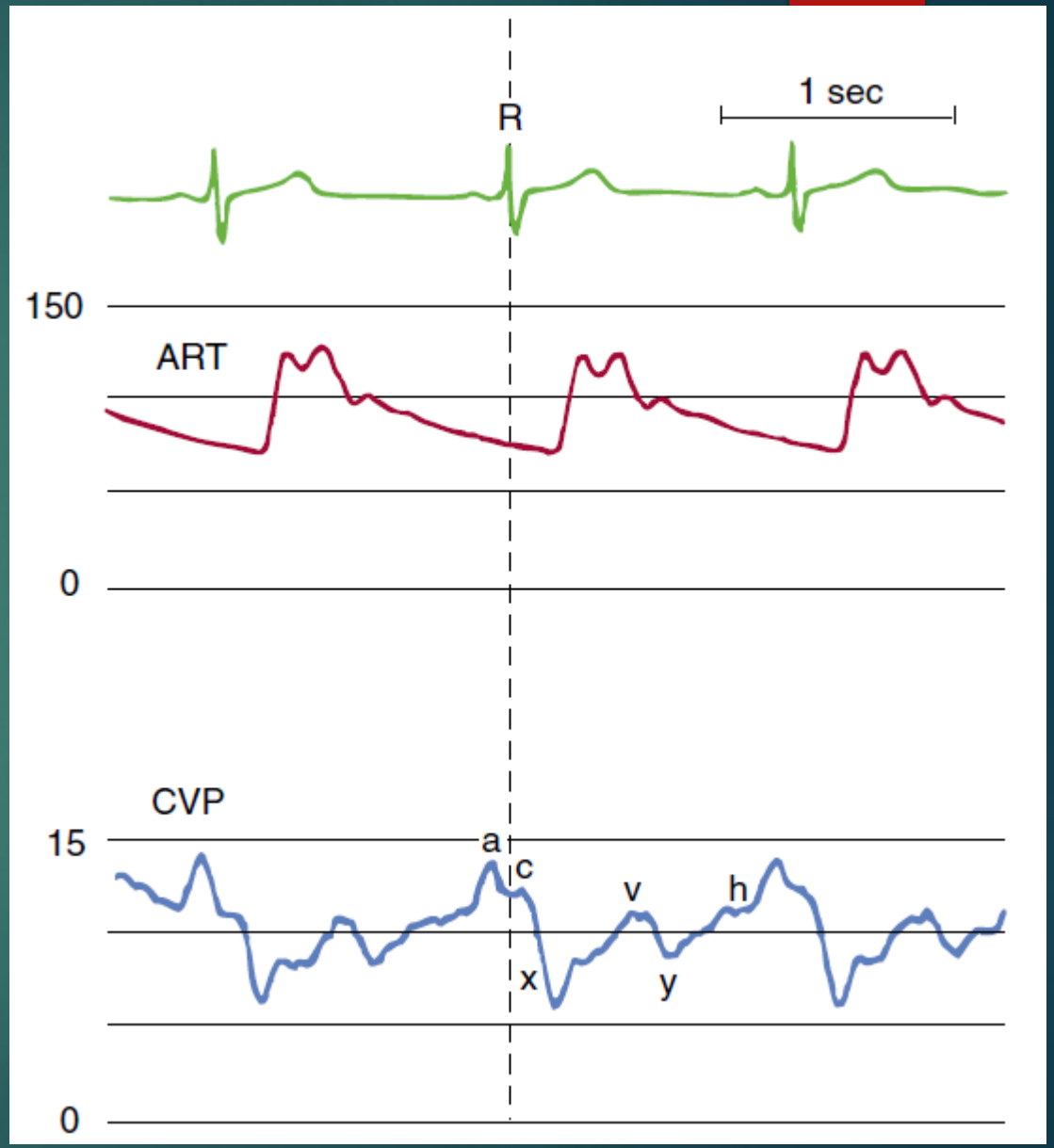
TVC

- Pression remplissage ≠ volume remplissage
- Ne pas regarder chiffre → regarder forme courbe et tendance
- Attention arythmie, rythme pace, sténose ou insuffisance tricuspidienne
- Interprétation TVC et Wedge influences par plusieurs variables
  - Compliance ventriculaire
  - Anomalie valvulaire
  - Ventilation pression positive
  - Etc.
- Penser à :
  - variation respiratoire des paramètres HD
  - Leg raise test
  - Pseudo hypovolémie en défaillance VD

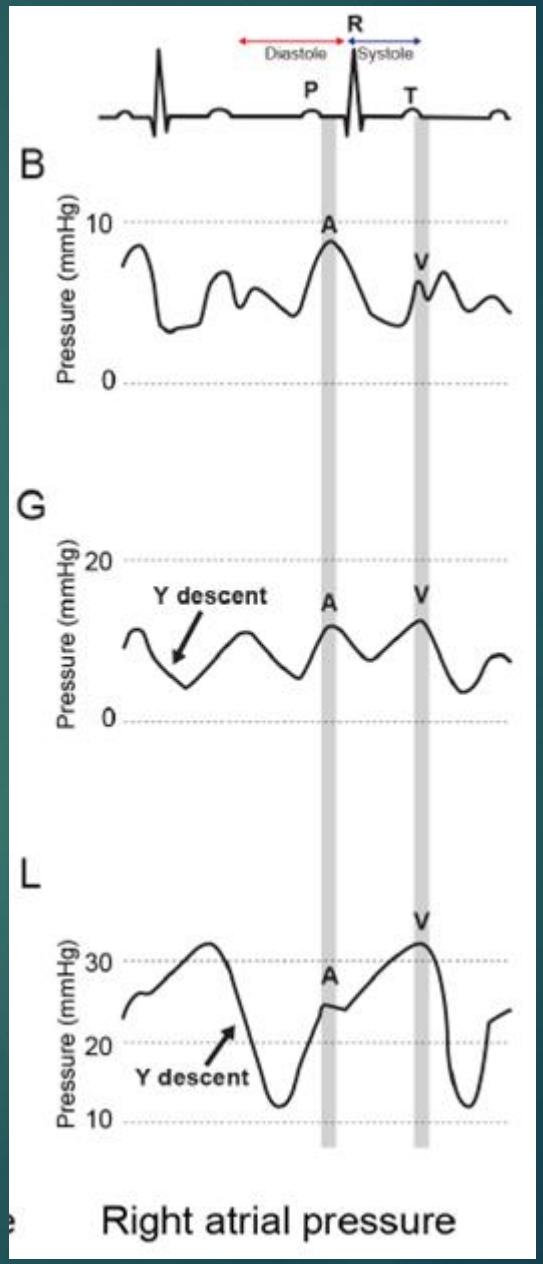


TVC

Waveform Component	Phase of Cardiac Cycle	Mechanical Event
a wave	End diastole	Atrial contraction
c wave	Early systole	Isovolumic ventricular contraction, tricuspid motion toward the right atrium
v wave	Late systole	Systolic filling of the atrium
h wave	Mid to late diastole	Diastolic plateau
x descent	Mid systole	Atrial relaxation, descent of the base, systolic collapse
y descent	Early diastole	Early ventricular filling, diastolic collapse

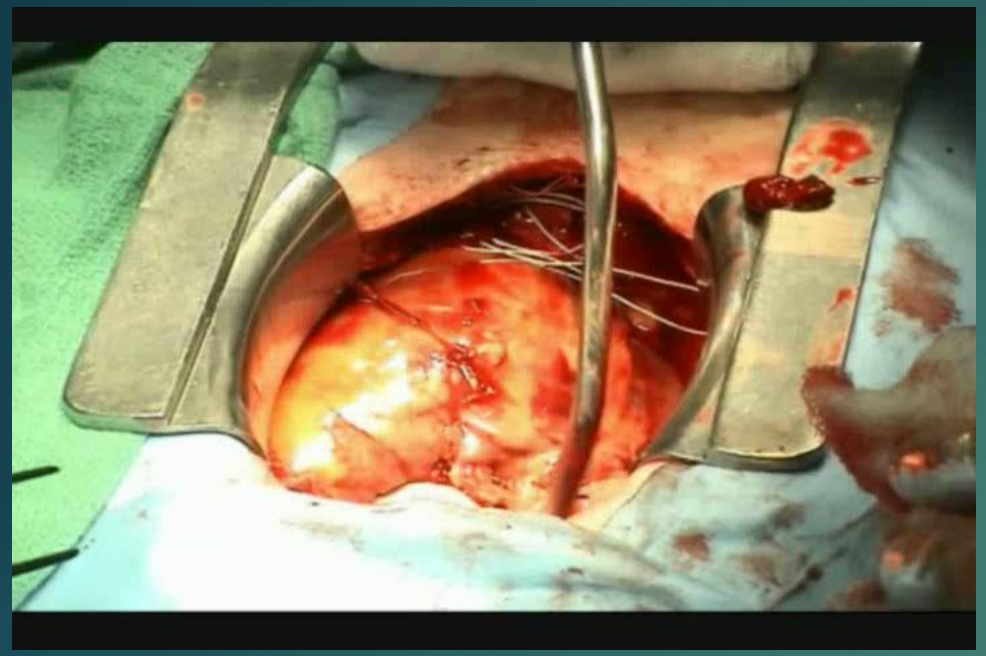


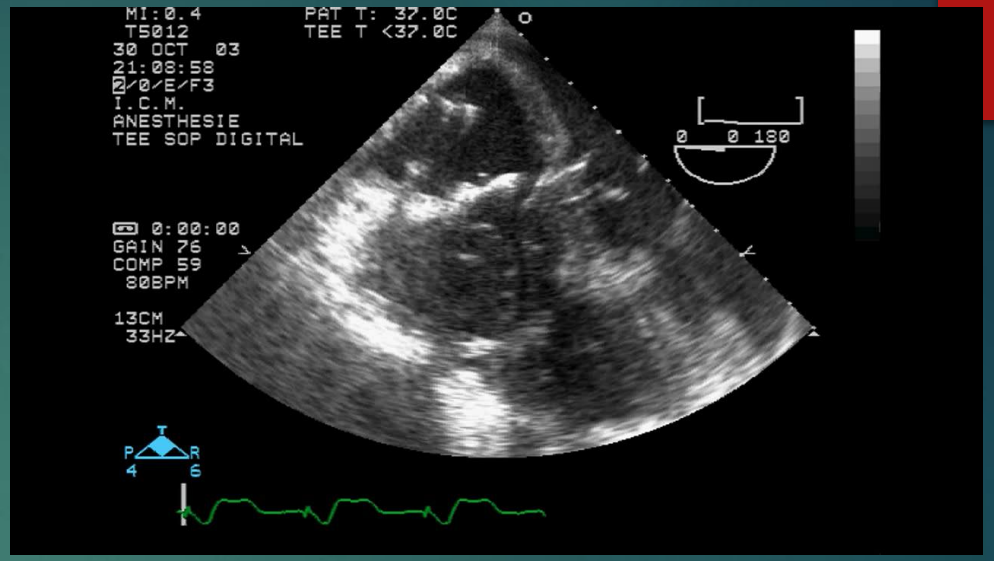
Condition	Characteristics
Atrial fibrillation	Loss of a wave Prominent c wave
Atrioventricular dissociation	Cannon a wave
Tricuspid regurgitation	Tall systolic c-v wave Loss of x descent
Tricuspid stenosis	Tall a wave Attenuation of y descent
Right ventricular ischemia	Tall a and v waves Steep x and y descents M or W configuration
Pericardial constriction	Tall a and v waves Steep x and y descents M or W configuration
Cardiac tamponade	Dominant x descent Attenuated y descent
Respiratory variation during spontaneous or positive-pressure ventilation	Measure pressures at end-expiration

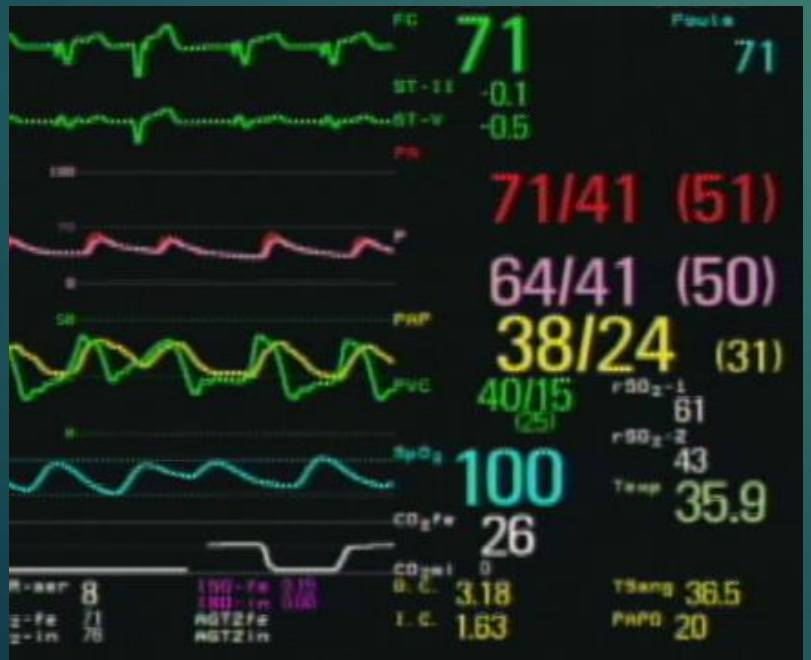


Monere

Racine carrée




MI:0.4
T5012
PAT T: 37.0C
TEE T <37.0C
30 OCT 03
21:08:58
2/0/E/F3
I.C.M.
ANESTHESIE
TEE SOP DIGITAL
0 0 180
0:00:00
GAIN 76
COMP 59
80BPM
13CM
33HZ
P 4
R 6


71
71
-0.1
-0.5
71/41 (51)
64/41 (50)
38/24 (31)
40/15 (25)
100
26
3.18
1.63
36.5
20


Masimo
97
74
15
13.4
1.0
20
4.0
18
36
0
0
0.0
16.0
13.0
67
30
30
65
-2
22
32
Radical-7
SedLine

Importance courbe VD : monitoring PVD

- Courbe VD
  - Dysfonction diastolique VD
  - Couplage ventriculo-artériel
  - Obstruction CCVD

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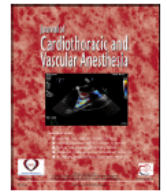
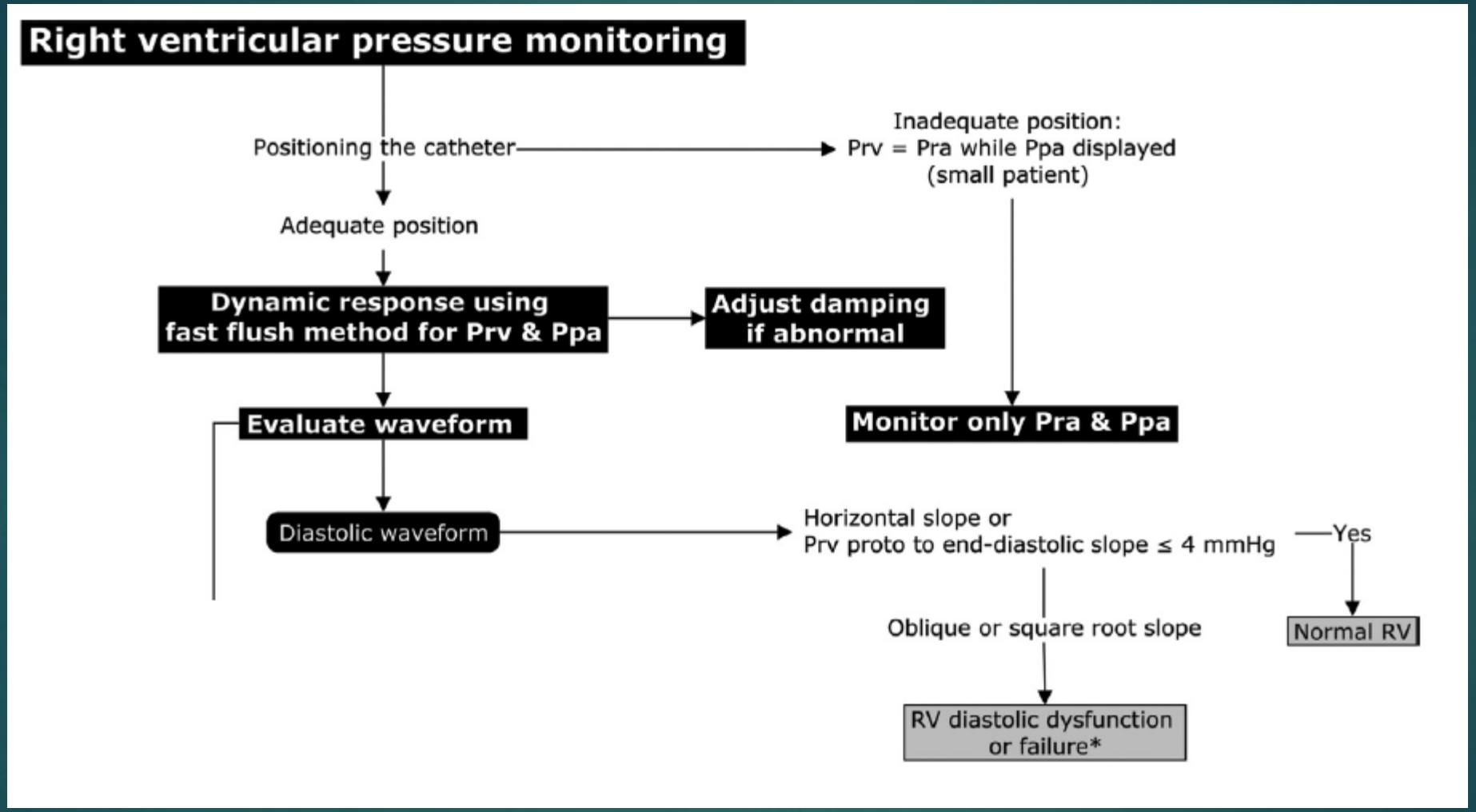


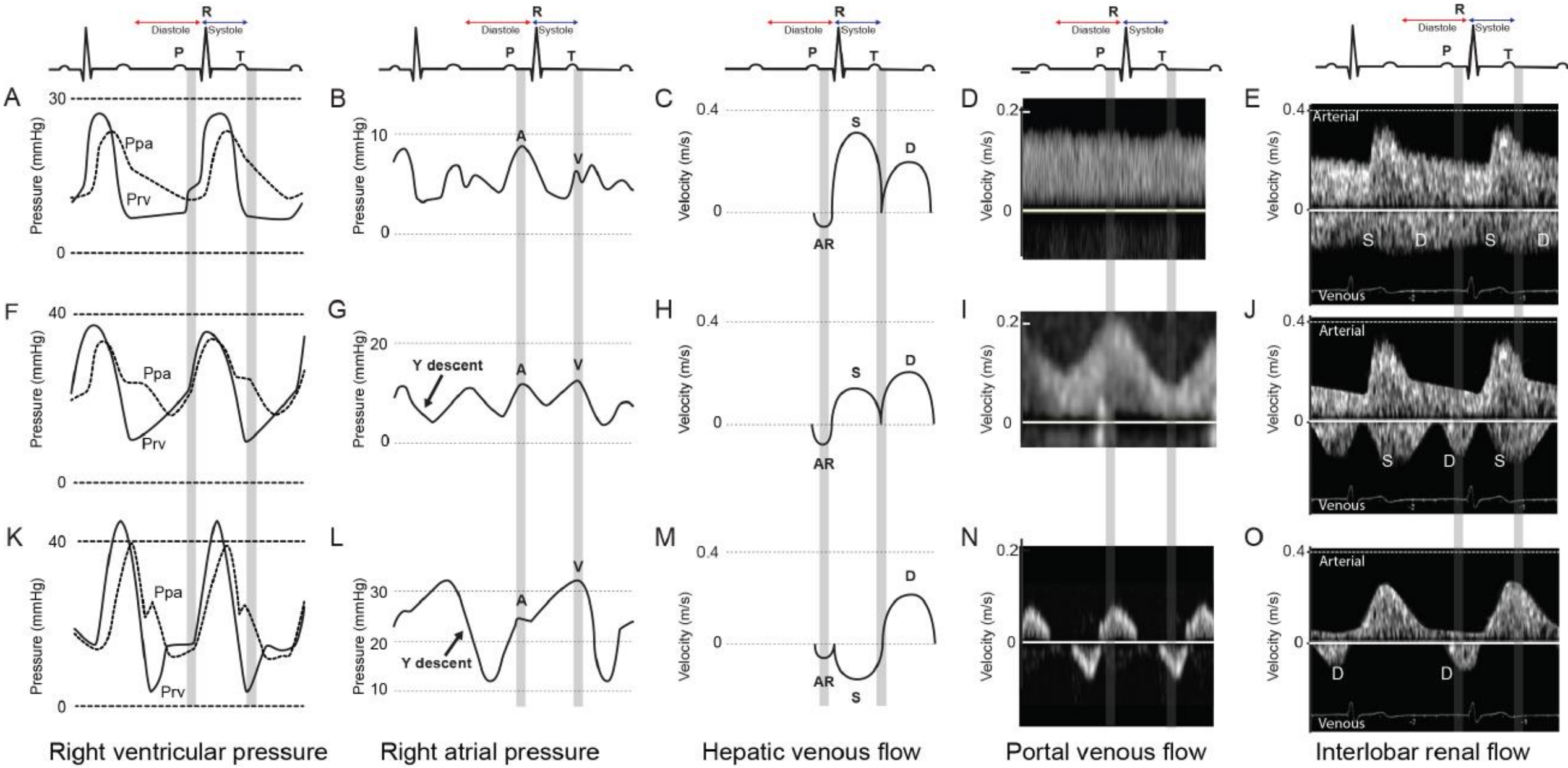
Review Article

Perioperative Right Ventricular Pressure Monitoring in Cardiac Surgery

Meggie Raymond, MD[*], Lars Grønlykke, MD[†], Etienne J. Couture, MD[‡], Georges Desjardins, MD[*], Jennifer Cogan, MD[*], Jennifer Cloutier, MD[§], Yoan Lamarche, MD[‖], Philippe L. L'Allier, MD[¶], Hanne Berg Ravn, MD, PhD[†], Pierre Couture, MD[*], Alain Deschamps, MD, PhD[*], Marie-Eve Chamberland, MD[*], Christian Ayoub, MD[*], Jean-Sébastien Lebon, MD[*], Marco Julien, MD[*], Jean Taillefer, MD[*], Antoine Rochon, MD[*], André Y. Denault, MD, PhD[#,1]

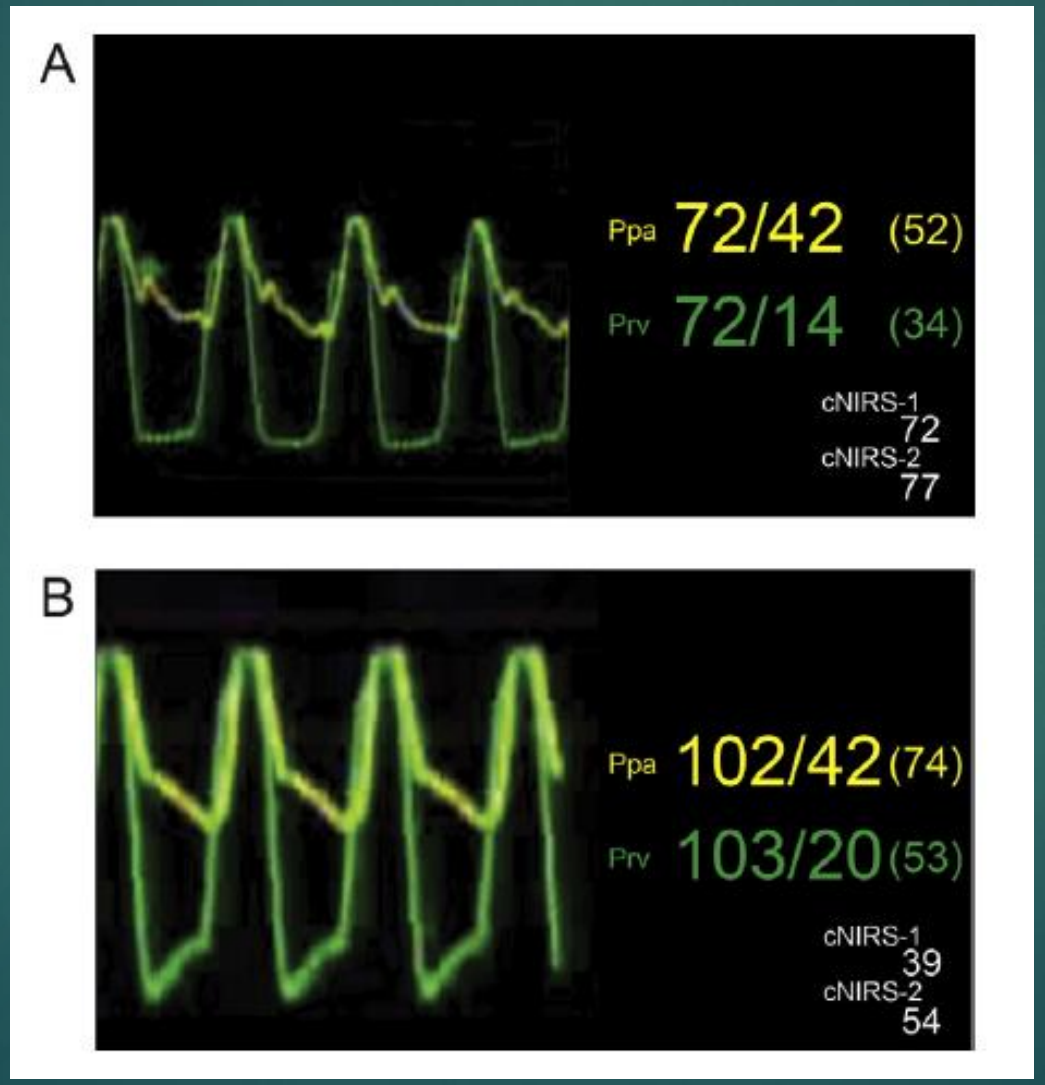

Right ventricular pressure monitoring
Positioning the catheter
Inadequate position:
Prv = Pra while Ppa displayed
(small patient)
Adequate position
Dynamic response using
fast flush method for Prv & Ppa
Adjust damping
if abnormal
Evaluate waveform
Monitor only Pra & Ppa
Diastolic waveform
Horizontal slope or
Prv proto to end-diastolic slope ≤ 4 mmHg
Yes
Oblique or square root slope
Normal RV
RV diastolic dysfunction
or failure*

Dysfonction VD

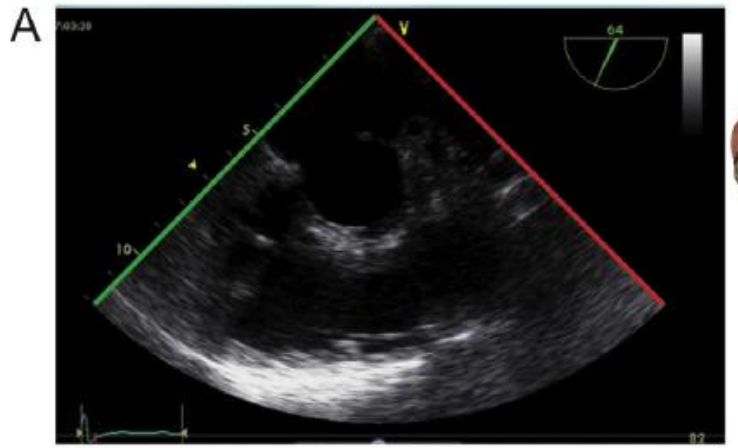


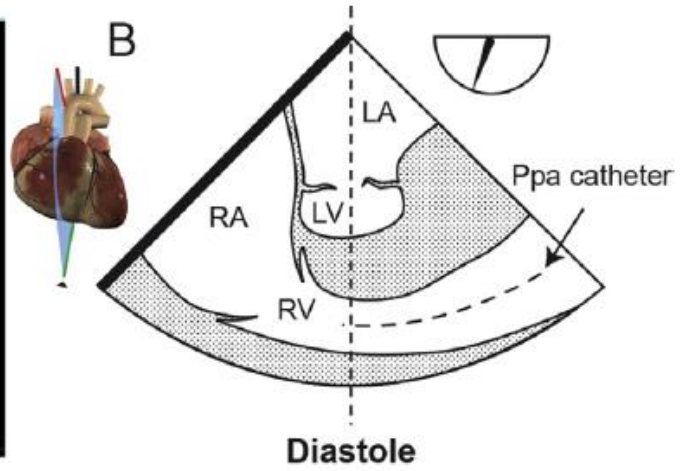
Right ventricular pressure | Right atrial pressure | Hepatic venous flow | Portal venous flow | Interlobar renal flow

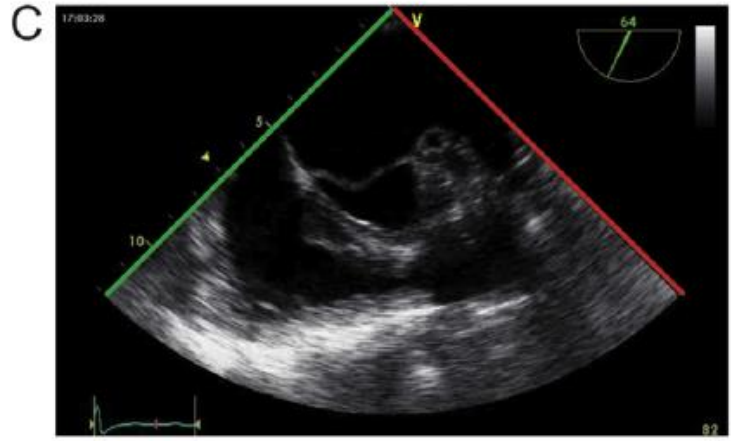
Couplage ventriculo-artériel

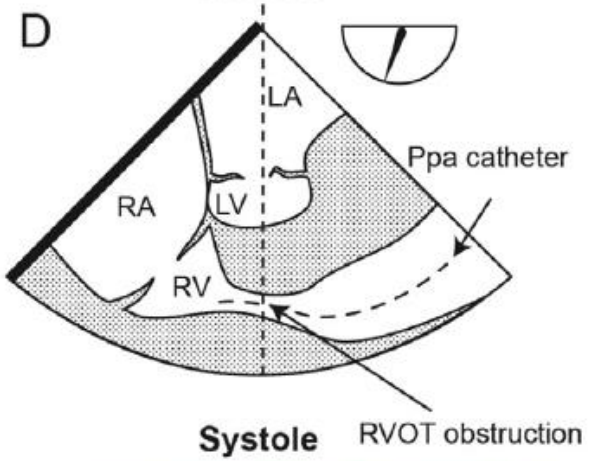


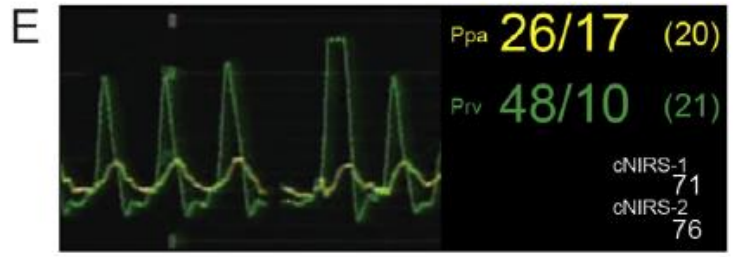
RVOTO

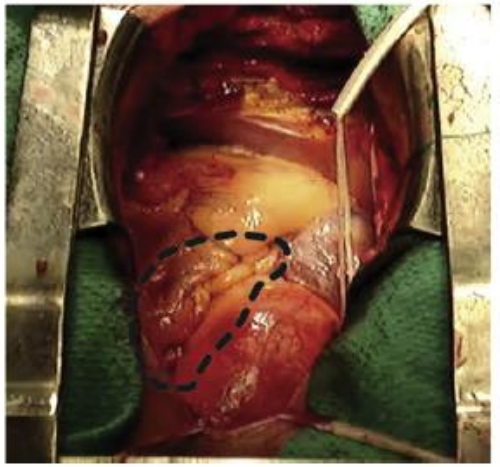

A

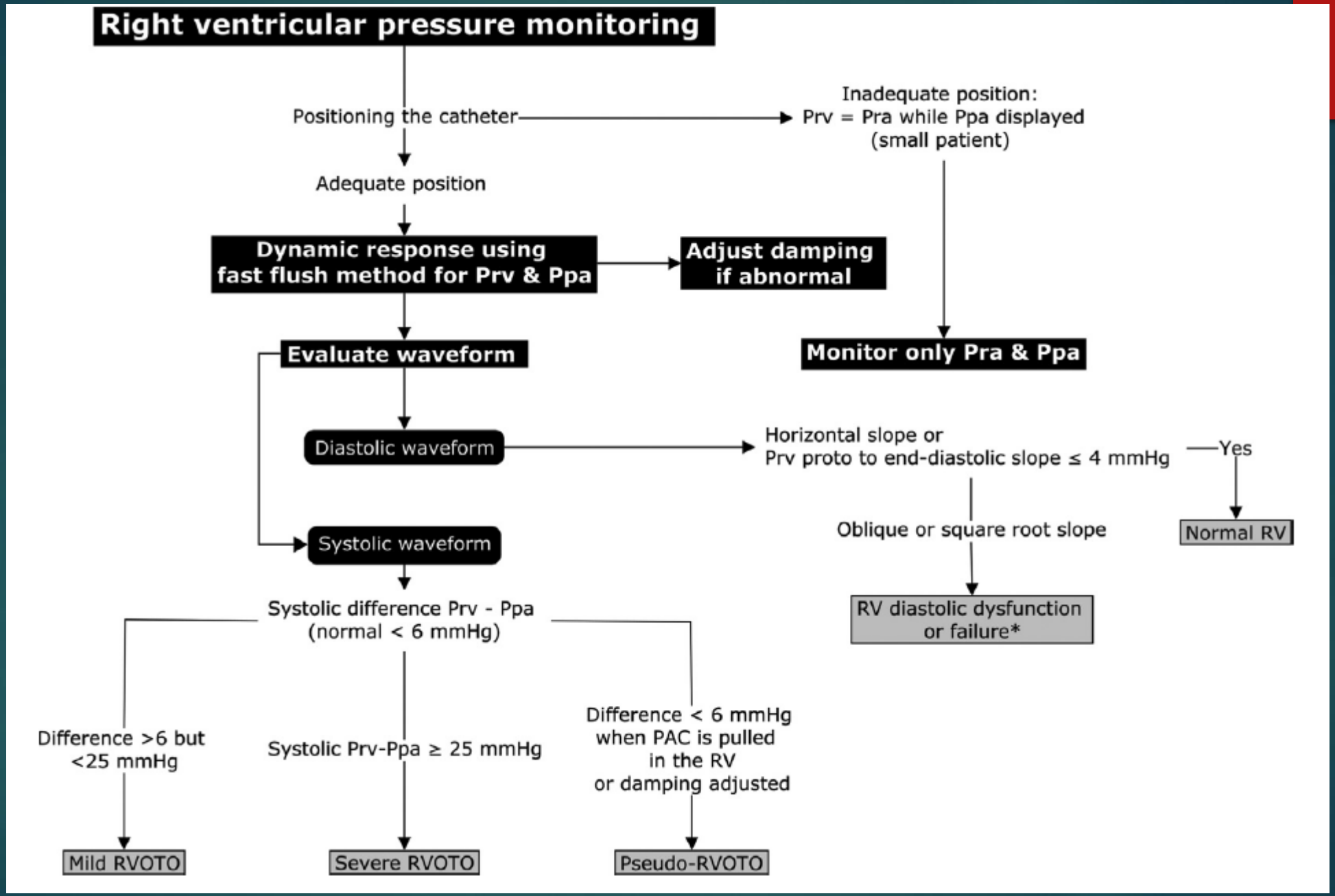

B
LA
Ppa catheter
RA
LV
RV
Diastole


C


D
LA
Ppa catheter
RA
LV
RV
Systole
RVOT obstruction


E
Ppa 26/17 (20)
Prv 48/10 (21)
cNIRS-1
71
cNIRS-2
76


F


Right ventricular pressure monitoring
Positioning the catheter
Inadequate position:
Prv = Pra while Ppa displayed
(small patient)
Adequate position
Dynamic response using
fast flush method for Prv & Ppa
Adjust damping
if abnormal
Evaluate waveform
Monitor only Pra & Ppa
Diastolic waveform
Horizontal slope or
Prv proto to end-diastolic slope ≤ 4 mmHg
Yes
Normal RV
Oblique or square root slope
RV diastolic dysfunction
or failure*
Systolic waveform
Systolic difference Prv - Ppa
(normal < 6 mmHg)
Difference >6 but
<25 mmHg
Systolic Prv-Ppa ≥ 25 mmHg
Difference < 6 mmHg
when PAC is pulled
in the RV
or damping adjusted
Mild RVOTO
Severe RVOTO
Pseudo-RVOTO

Quiz

Which is most likely a cause of low mixed venous saturation (SvO2)?

- A. cirrhosis
- B. anemia
- C. sepsis
- D. cyanide toxicity

Which is most likely a cause of low mixed venous saturation (SvO2)?

- A. cirrhosis
- **B. anemia**
- C. sepsis
- D. cyanide toxicity

$SvO_2 = SaO_2 - VO_2 / (DC \cdot 1.34 \cdot Hb)$
valeur normale: ≥ 65 %

Cette formule démontre que la SvO_2 n'est pas une mesure univoque; sa baisse peut résulter de quatre facteurs différents:

- L'hypoxémie,
- L'élévation de la VO_2,
- La baisse du débit cardiaque,
- L'anémie.

What is true with respect to mixed venous O2 saturation?

- A. Varies indirectly with arterial Hb saturation
- B. Varies inversely with O2 consumption
- C. Decreased in a patient with limb ischemia
- D. Varies inversely to CO

What is true with respect to mixed venous O2 saturation?

- A. Varies indirectly with arterial Hb saturation
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$$S\bar{v}O_2 = SaO_2 - \frac{\dot{V}O_2}{\dot{Q} \times 1.36 \times Hb}$$

where $S\bar{v}O_2$ = mixed venous hemoglobin saturation (%)
SaO_2 = arterial hemoglobin saturation (%)
$\dot{V}O_2$ = oxygen consumption (mL O_2/min)
$\dot{Q}$ = cardiac output (L/min)
Hb = hemoglobin concentration (g/dL)

Calculate VO2 if CaO2 100%, CvO2 40%, Hgb 100 g/L, and CO 5 L/min

- A. 100 ml/min
- B. 200 ml/min
- C. 300 ml/min
- D. 400 ml/min
- E. Not enough information to calculate

Calculate VO2 if SaO2 100%, SvO2 40%, Hgb 100 g/L, and CO 5 L/min

- A. 100 ml/min
- B. 200 ml/min
- C. 300 ml/min
- **D. 400 ml/min**
- E. Not enough information to calculate

$VO_2 = (CaO_2 - CvO_2) \cdot DC$ où CvO_2 : contenu en O_2 du sang veineux mêlé

Donc:
$VO_2 = (1.34 \cdot Hb) \cdot (SaO_2 - SvO_2) \cdot DC$
valeur normale: 3.5 mL/kg/min ou 250 mL/min
valeur normale SvO_2: 70%

All of the following will cause the PA catheter to underestimate LVEDP except?

- A. Aortic regurgitation
- B. Mitral stenosis
- C. RBBB
- D. Decreased LV compliance

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Sous-estimer la PTDVG = PAP/Wedge N mais PTDVG élevée en vérité!

Dans toutes ces situations, PAP/Wedge N et PTDVG haute

Trouver dans quelle situation PAP/Wedge haute et PTDVG basse en vérité

All of the following will cause the PA catheter to underestimate LVEDP except?

- A. Aortic regurgitation (Wedge N/PTDVG ↑)
- **B. Mitral stenosis** (Wedge ↑ /PTDVG N)
- C. RBBB (PAPD↓ /PTDVG N)
- D. Decreased LV compliance (Wedge N/PTDVG ↑)

Table 40-5 Underestimation of Left Ventricular End-Diastolic Pressure

Condition	Site of Discrepancy	Cause of Discrepancy
Diastolic dysfunction	Mean LAP < LVEDP	Increased end-diastolic a wave
Aortic regurgitation	LAP a wave < LVEDP	Mitral valve closure before end-diastole
Pulmonic regurgitation	PADP < LVEDP	Bidirectional runoff for pulmonary artery flow
Right bundle branch block	PADP < LVEDP	Delayed pulmonic valve opening
After pneumonectomy	PAWP < LAP or LVEDP	Obstruction of pulmonary blood flow

What is a pathology associated with cannon a waves?

- A. Atrial fibrillation
- B. AV dissociation
- C. Diastolic dysfunction
- D. Tamponade

What is a pathology associated with cannon a waves?

- A. Atrial fibrillation
- **B. AV dissociation**
- C. Diastolic dysfunction
- D. Tamponade

Condition	Characteristics
Atrial fibrillation	Loss of a wave Prominent c wave
Atrioventricular dissociation	Cannon a wave
Tricuspid regurgitation	Tall systolic c-v wave Loss of x descent
Tricuspid stenosis	Tall a wave Attenuation of y descent
Right ventricular ischemia	Tall a and v waves Steep x and y descents M or W configuration
Pericardial constriction	Tall a and v waves Steep x and y descents M or W configuration
Cardiac tamponade	Dominant x descent Attenuated y descent
Respiratory variation during spontaneous or positive-pressure ventilation	Measure pressures at end-expiration

You are assessing an acutely unstable patient. CVP tracing shows loss of A wave and augmented C wave. What is likely diagnosis?

- A. A Fib
- B. PE
- C. Pneumothorax
- D. MI

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What is TRUE regarding the CVP tracing?

- A. A wave corresponds to atrial filling
- B. X descent corresponds to RV systole
- C. V wave corresponds with RV relaxation
- D. Y descent corresponds to closure of tricuspid valve

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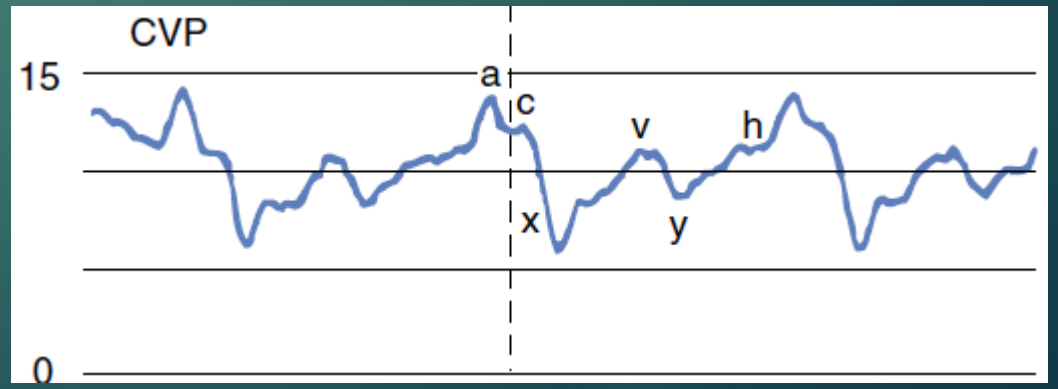
What is TRUE regarding the CVP tracing?

- A. A wave corresponds to atrial filling : NON contraction auriculaire
- **B. X descent corresponds to RV systole**
- C. V wave corresponds with RV relaxation : NON remplissage systolique oreillette
- D. Y descent corresponds to closure of tricuspid valve : NON ouverture VT et remplissage ventriculaire (vidange auriculaire début diastole)



Which point on CVP tracing corresponds to tricuspid closure in normal sinus rhythm?

- A. c wave
- B. v wave
- C. x descent
- D. y descent

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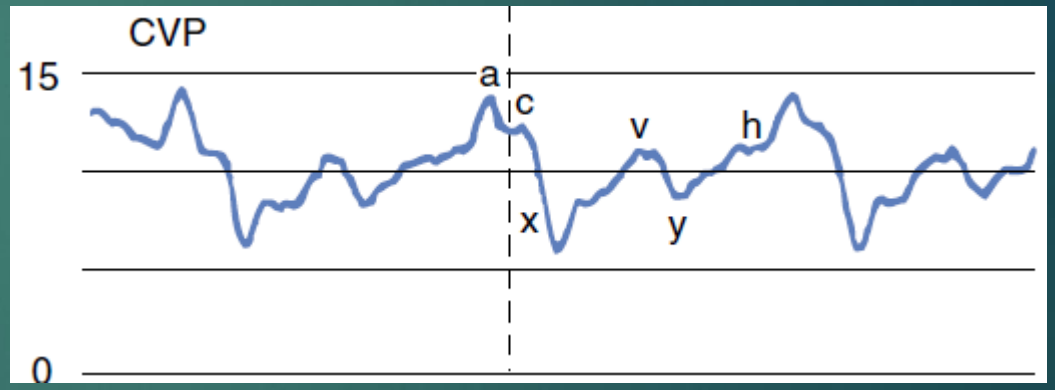
- D. y descent



Lequel des facteurs suivants entraînera une surestimation du débit cardiaque par la méthode de thermodilution?

- A. Extrémité du cathéter de l'artère pulmonaire dans la zone 2 du poumon
- B. N'injecter que la moitié du volume requis
- C. Mesure du débit cardiaque dans les toutes premières minutes après un pontage
- D. Utilisation de dextrose dans l'eau comme produit d'injection

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That's all Folks!