Monitorage hémodynamique: Pourquoi et quelle technique ?

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Introduction

- **EDC : Cause fréquente d'hospitalisation en réanimation.**
- **Le diagnostic est <u>clinique</u>.**
- **URGENCE thérapeutique.**
- **<u>Monitorage hémodynamique</u>:**
    - **Identification du type de choc pour les cas complexes.**
    - **Guider la prise en charge thérapeutique « hémodynamique ».**

Définition

Physiopathologique : Insuffisance circulatoire aiguë, périphérique, généralisée, responsable d'une dette tissulaire en oxygène.

→ Inadéquation entre apports et besoins en oxygène.

Clinique : Hypotension artérielle définie par une PAS < 90 mmHg ou une baisse de plus de 40 mmHg (ou de 30 %) par rapport aux chiffres antérieurs.

Donc…

Deux volets intriqués

La macro circulation

Hypotension

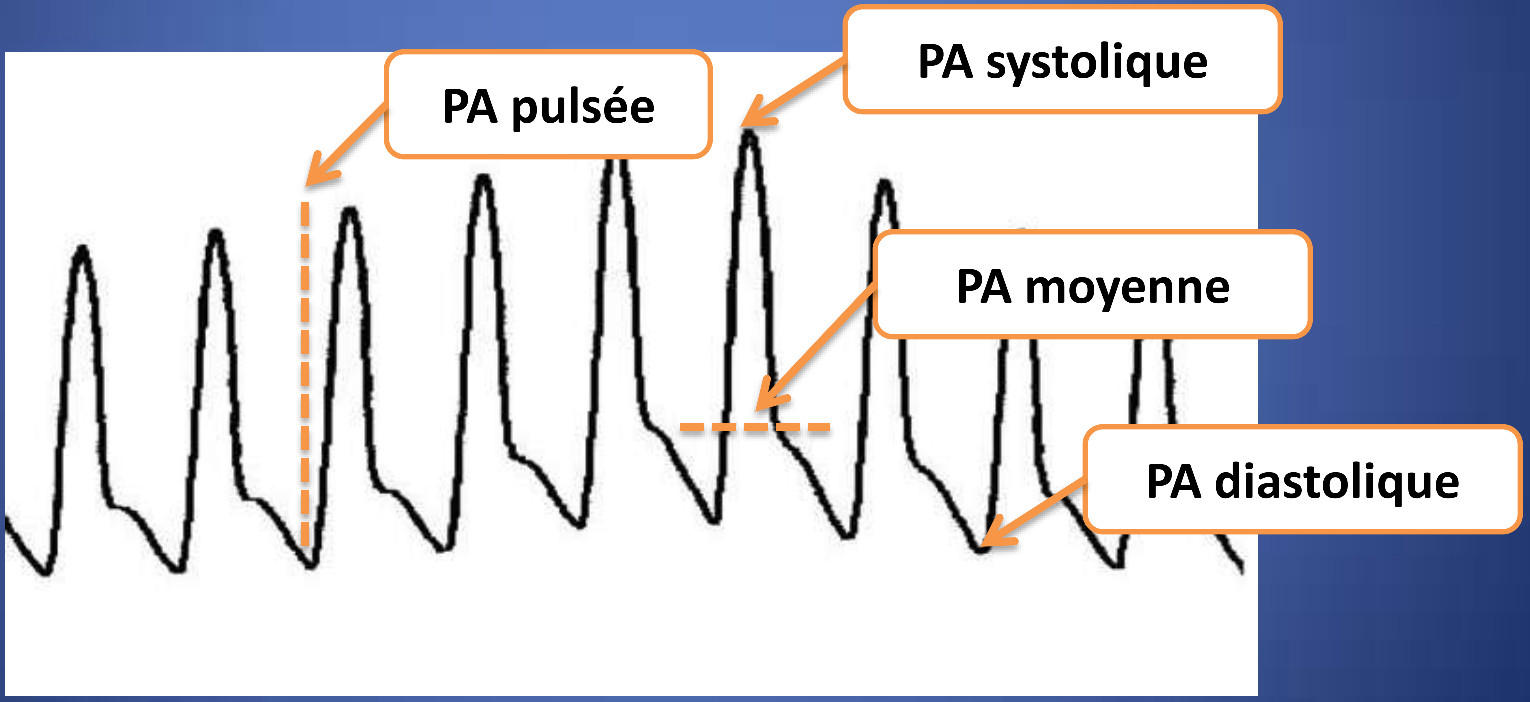
La micro circulation

Oxygénation tissulaire et cellulaire

Monitorage hémodynamique

- Doit-on utiliser un moyen de monitorage ?
- Que faut il monitorer: La mcro ou ma micro circulation ?
- Quel moyen de monitorage utiliser ?

Mesure de la pression artérielle



PAM = (PAS + 2 PAD)/3

Review

Clinical review: Interpretation of arterial pressure wave in shock states

Bouchra Lamia[1], Denis Chemla[2], Christian Richard[3] and Jean-Louis Teboul[3]

Critical Care December 2005 Vol 9 No 6

PAM = DC x RVS

PAM = (FC x VES) x RVS

Deux variables mesurables pour cette équation: PAM et DC.

Compliance vasculaire = ΔV/ΔP (syst/diastole)

Compliance vasculaire = VES/PP

PP = VES/C

PP est % au VES

PAM : Pression de perfusion de l'ensemble des organes (sauf pour les coronaires).

PAS: Résistance à l'éjection du ventricule gauche.

PAD: Reflet du tonus vasculaire.

PP: Reflet du VES.

A titre d'exemple :

Patient A

PAS = 80 mmHg

PAD = 35 mmHg

PAM = 50 mmHg

PP = 45 mmHg

→ **Vasopresseurs**

Patient A

PAS = 80 mmHg

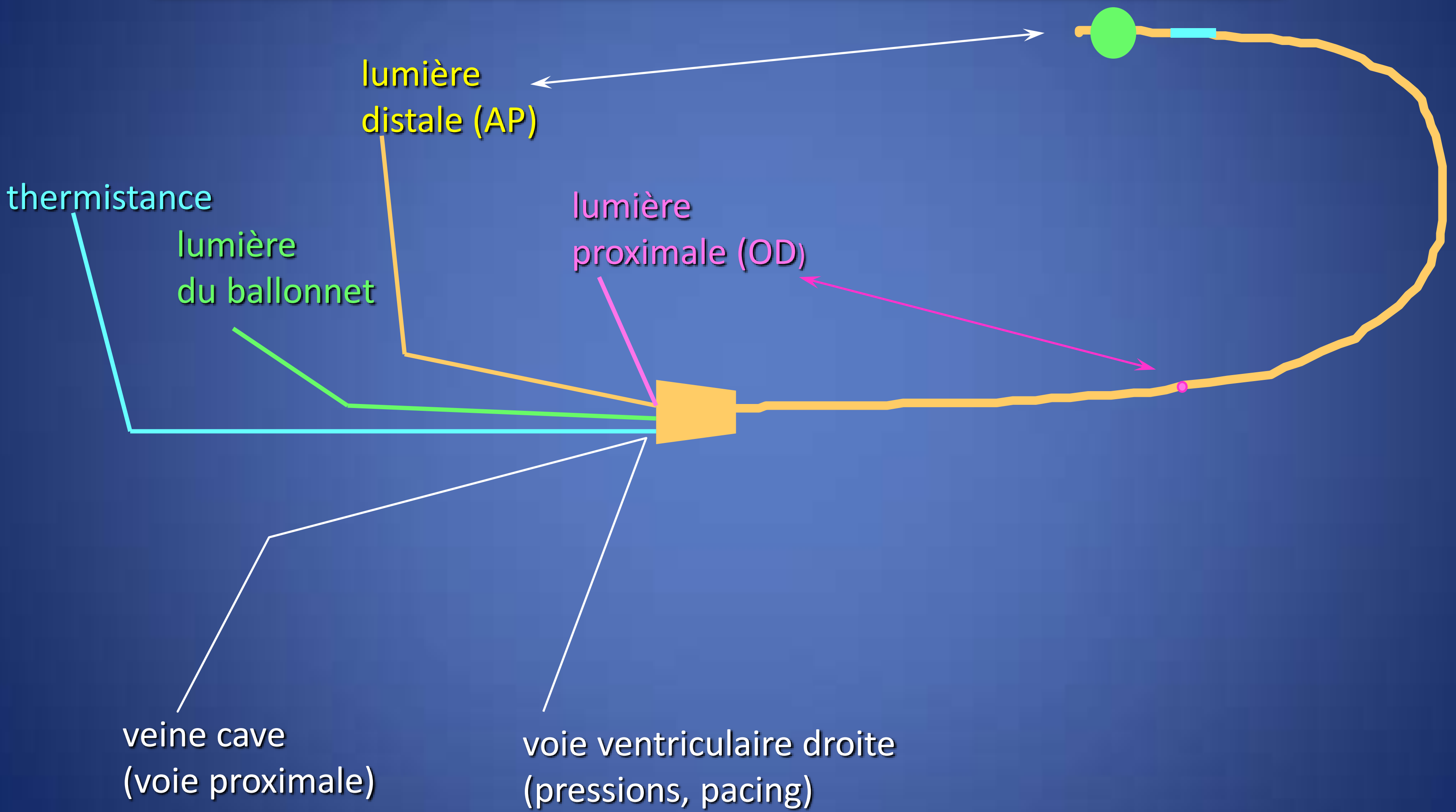
PAD = 60 mmHg

PAM = 67 mmHg

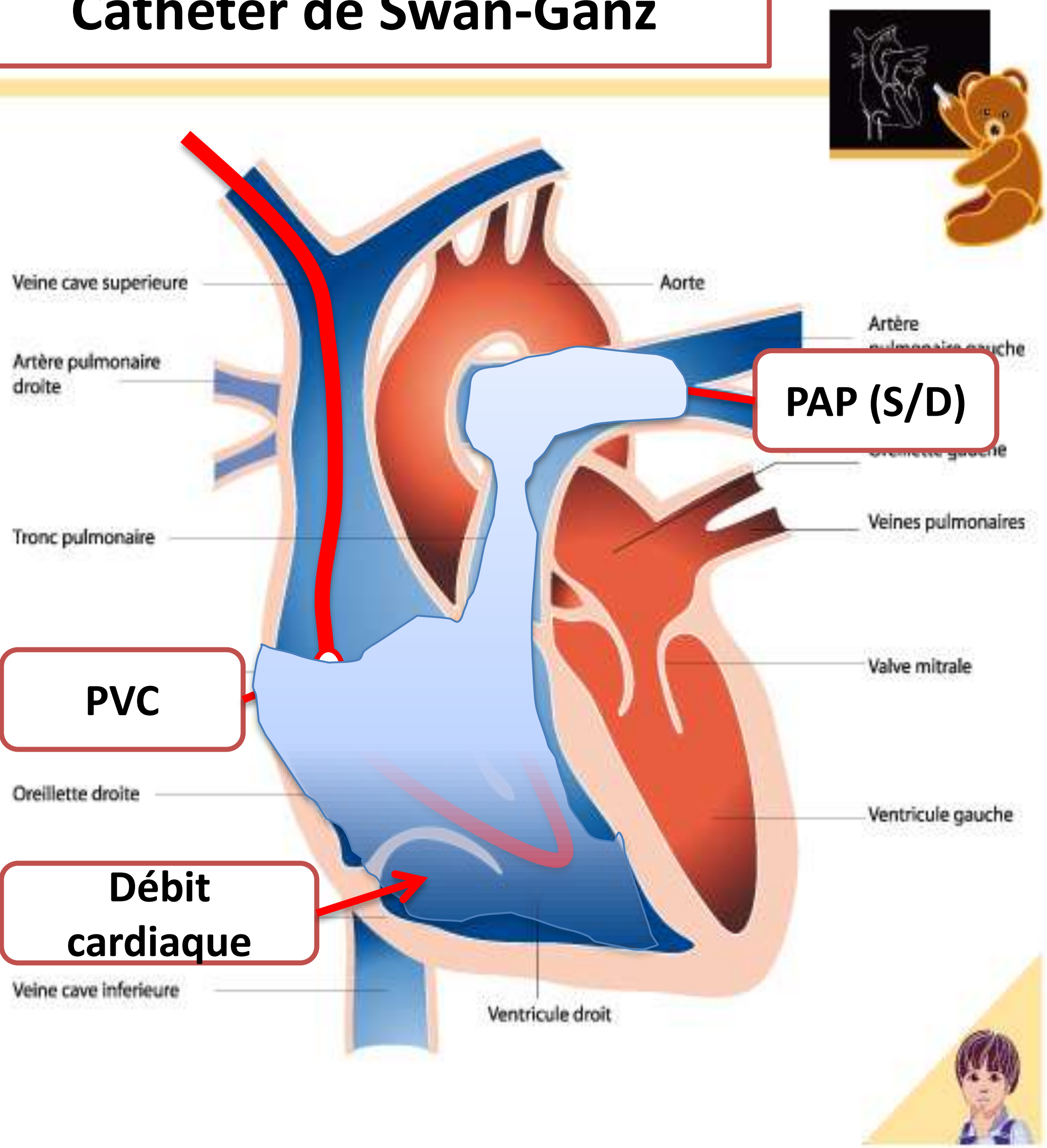
PP = 20 mmHg

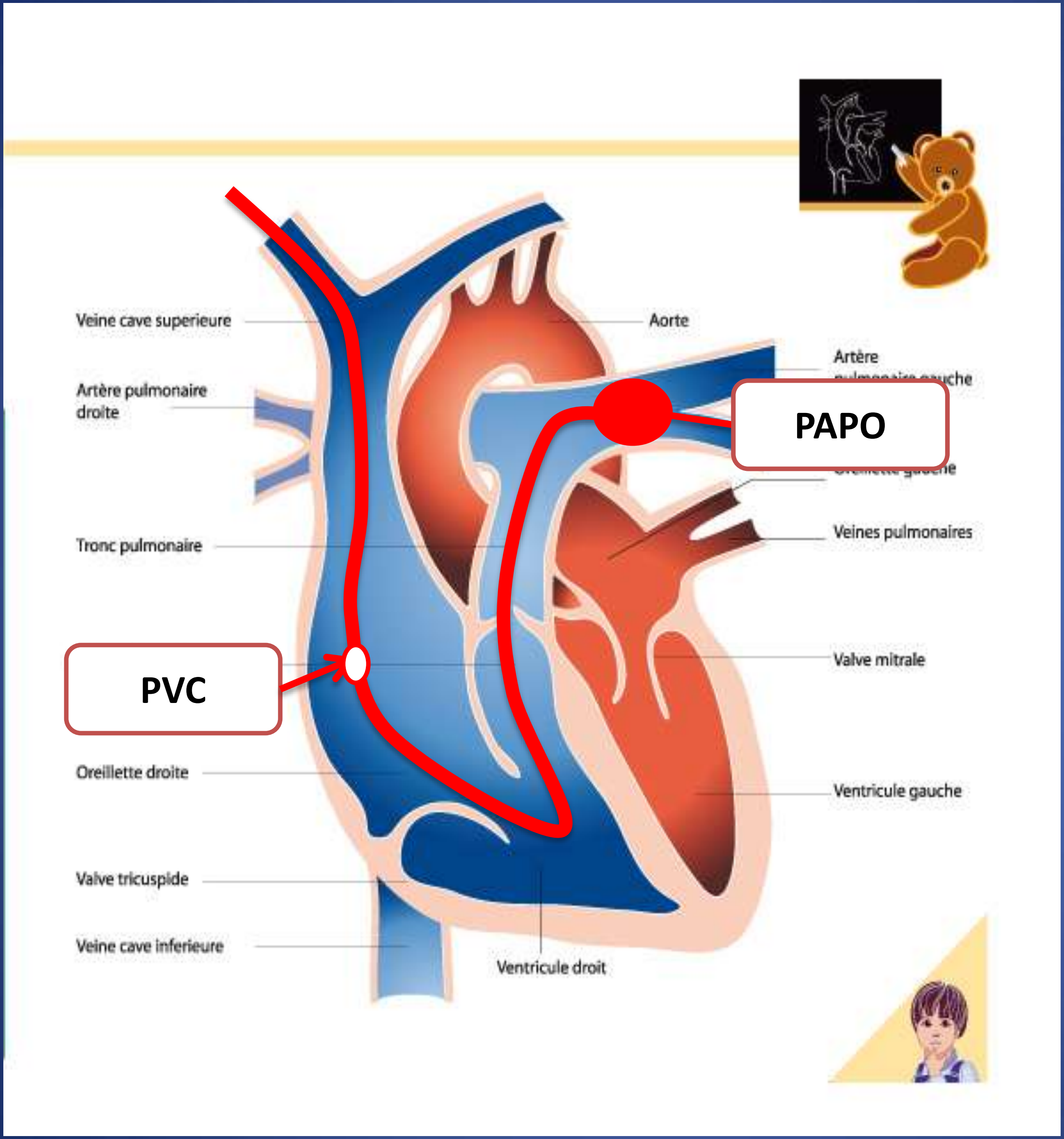
→ **Remplissage ou I(+) selon contexte**

Explorations hémodynamiques invasives



Cathéter de Swan-Ganz





Veine cave superieure
Aorte
Artère
Artère pulmonaire droite
PAPO
Veines pulmonaires
Tronc pulmonaire
Valve mitrale
PVC
Oreillette droite
Ventricule gauche
Valve tricuspide
Veine cave inferieure
Ventricule droit

Explorations hémodynamiques invasives

	DC	PVC	PAPO
Choc hypovolémique	↘	↘	↘
Choc cardiogénique	↘	↗	↗
Choc septique (phase initiale)	↗	↘	↘
Choc septique (phase tardive	↘	↘	↘

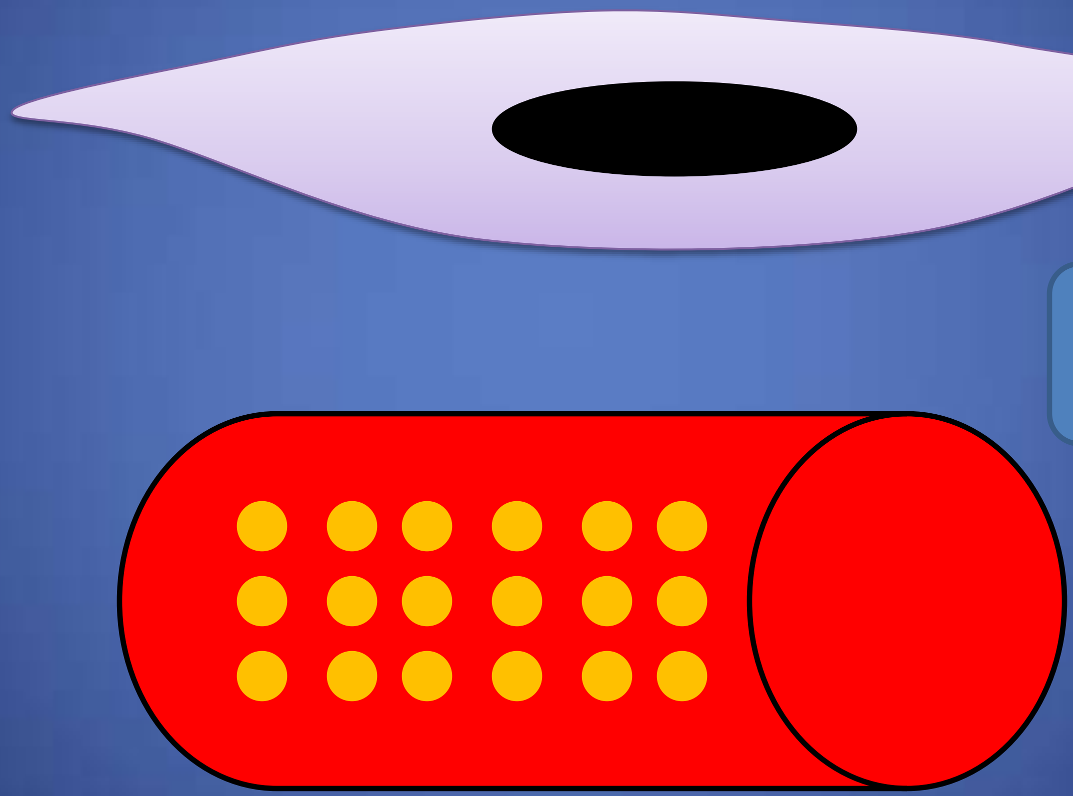
Paramètres d'oxygénation

Pour rappel :

$$CaO_2 = (PaO_2 \times 0{,}003) + (SaO_2 \times Hb \times 1{,}34)$$

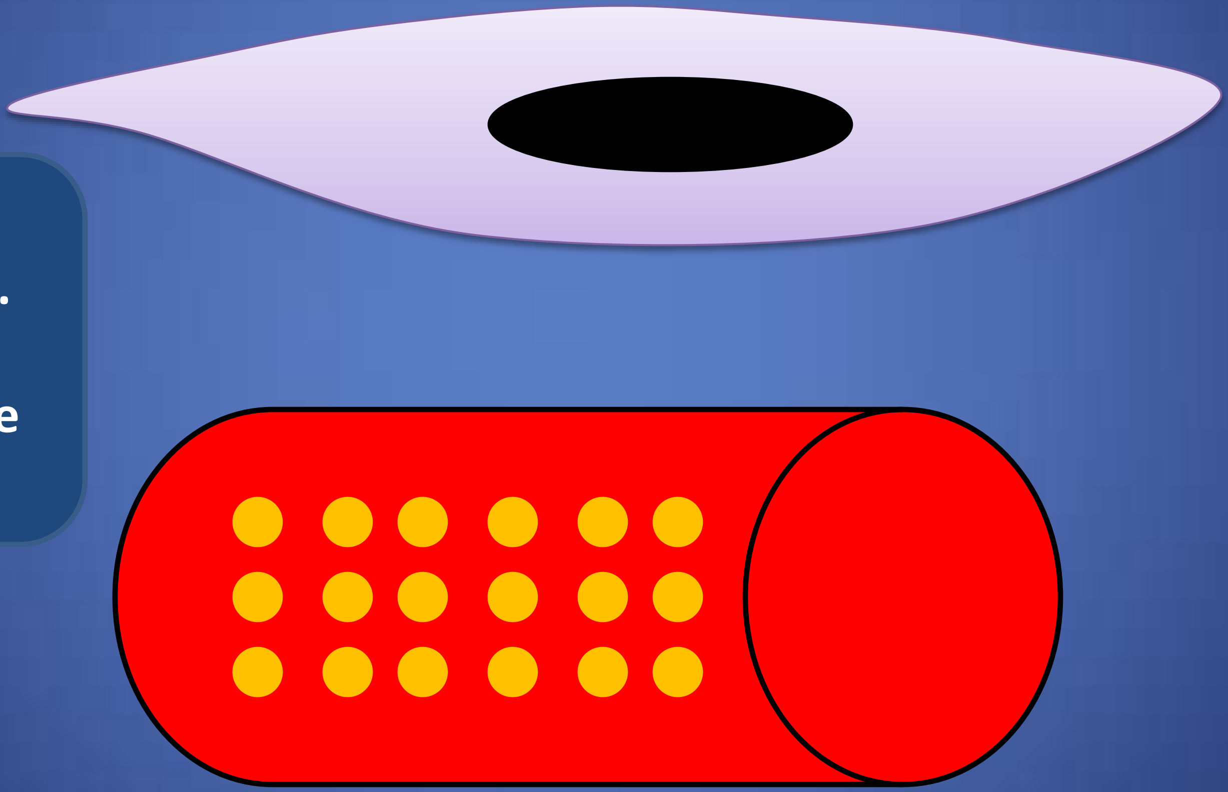
$$TaO_2 = CaO_2 \times DC$$

$$EO_2 = (TaO_2 - TvO_2)/TaO_2$$



EO2 = 25 %

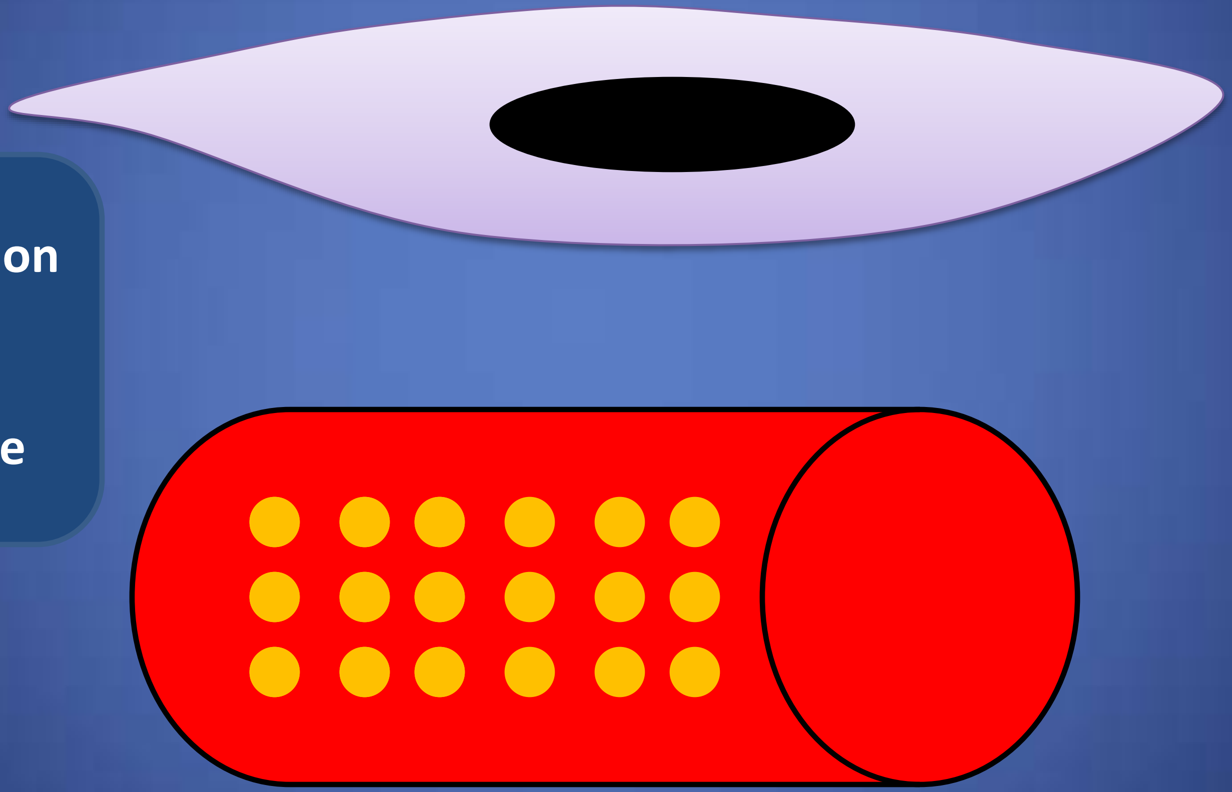
Si état de choc « distributif »



- Baisse EO_2.
- SvO_2 élevée

Si état de choc « conductif »

- Augmentation de EO2
- SvO2 basse



Paramètres d'oxygénation

	DC	PVC	PAPO	EO2	DAV
Choc hypovolémique	↘	↘	↘	↗	↗
Choc cardiogénique	↘	↗	↗	↗	↗
Choc septique (phase initiale)	↗	↘	↘	↘	↘

Mesure de la SVO_2

$$TaO_2 = DC \times [(PaO_2 \times 0{,}003) + (SaO_2 \times Hb \times 1{,}34)]$$

$$TvO_2 = DC \times [(PvO_2 \times 00{,}3) + (SvO_2 \times Hb \times 1{,}34))$$

$$VO_2 = DC \times (TaO_2 - TvO_2)$$

$$SvO_2 = SaO_2 - \frac{VO_2}{DC \times Hb \times 1.34}$$

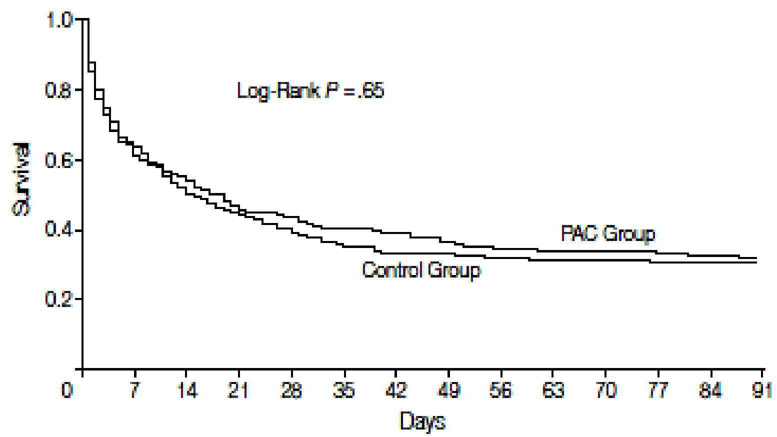
Impact du CAP sur la mortalité ?

Early Use of the Pulmonary Artery Catheter and Outcomes in Patients With Shock and Acute Respiratory Distress Syndrome

A Randomized Controlled Trial

(Reprinted) JAMA, November 26, 2003—Vol 290, No. 20

Kaplan-Meier Survival Estimates During 3 Months



No. of Patients Alive

PAC Group	335	198	168	136	99
Control Group	341	201	166	133	97

PAC indicates pulmonary artery catheter. The vital status at day 90 was known for all but 3 patients (1 in the PAC group and 2 in the control group).

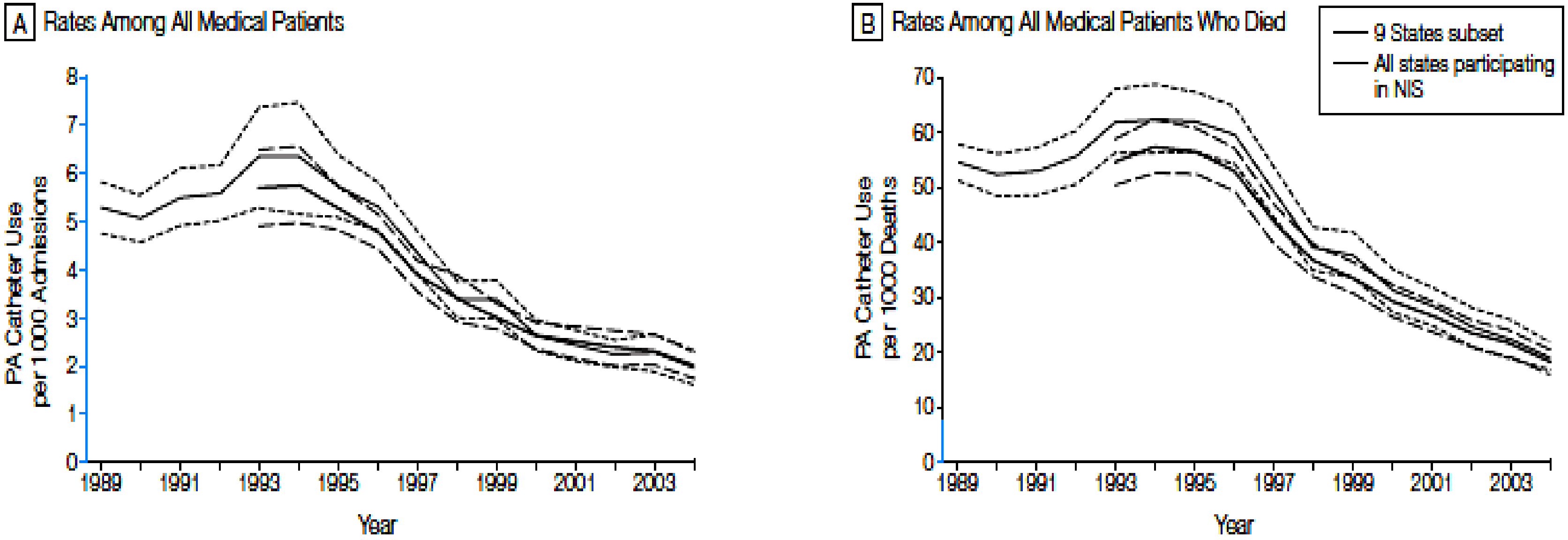
Trends in the Use of the Pulmonary Artery Catheter in the United States, 1993-2004

CARING FOR THE CRITICALLY ILL PATIENT

Renda Soylemez Wiener, MD
H. Gilbert Welch, MD, MPH

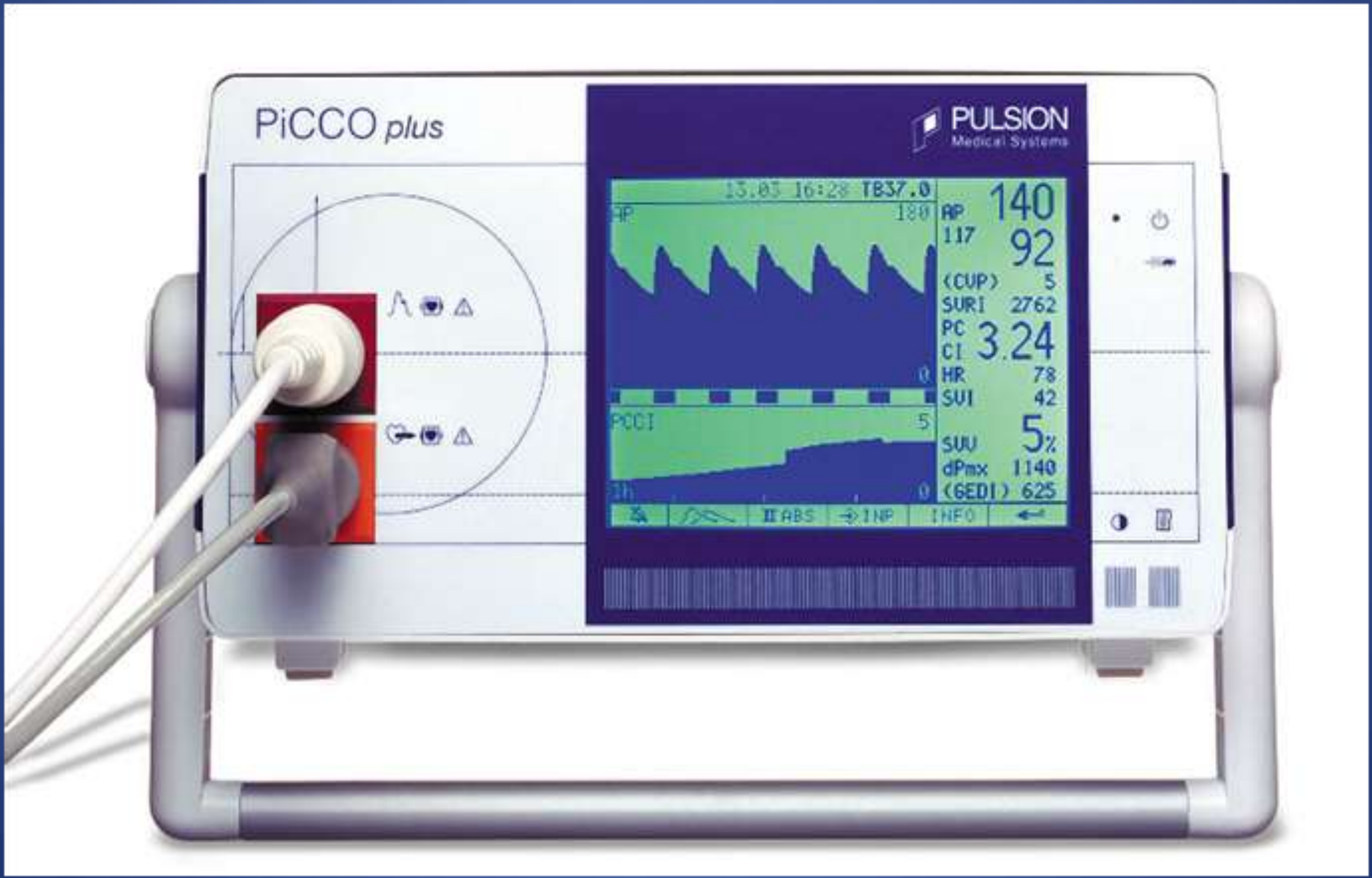
JAMA The Journal of the American Medical Association

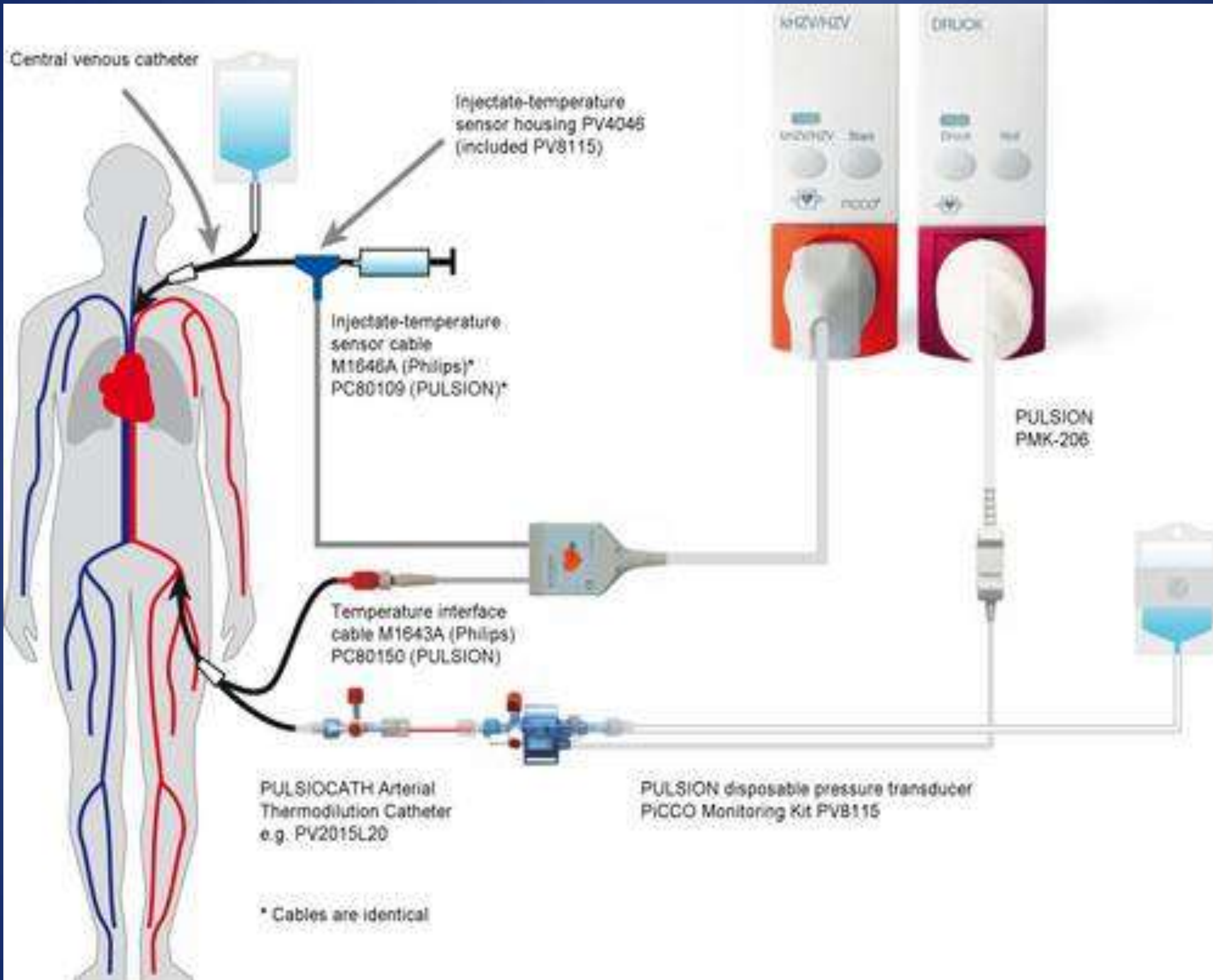
National Estimates of PA Catheter Use Among Medical Patients, 1989-2004



PA indicates pulmonary artery; NIS, Nationwide Inpatient Sample. Solid lines indicate PA catheters placed per 1000 patients and dashed lines indicate 95% confidence intervals around the annual rate. Y-axis intervals shown in blue indicate range from 0 to 8. An observational study suggested increased mortality with PA catheterization (abstract was presented in 1994[3] and the paper published in 1996[20]). Two randomized controlled trials (published in 2002 and in 2003)[11,12] showed no decrease in mortality with PA catheterization.

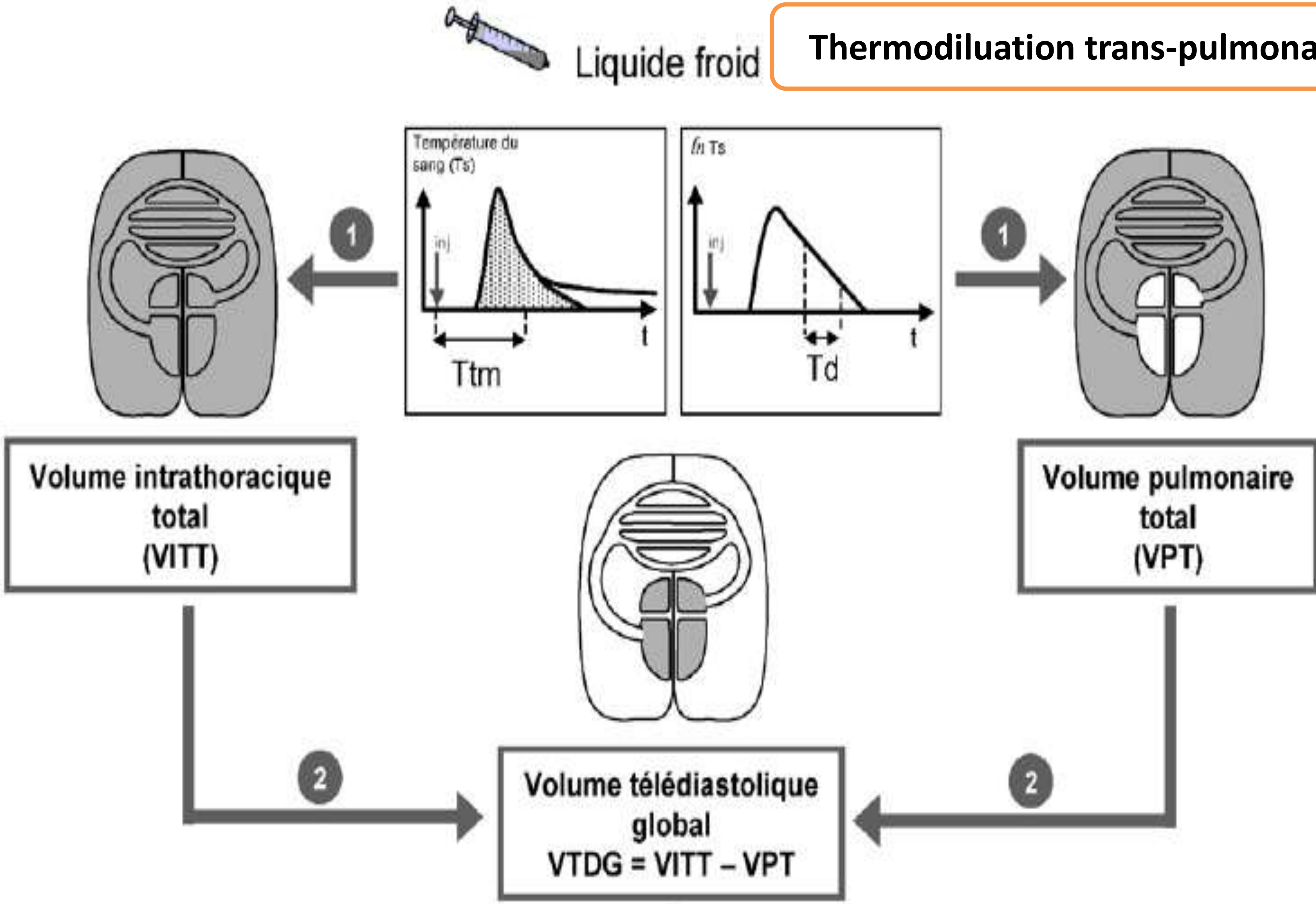
Système PiCCO

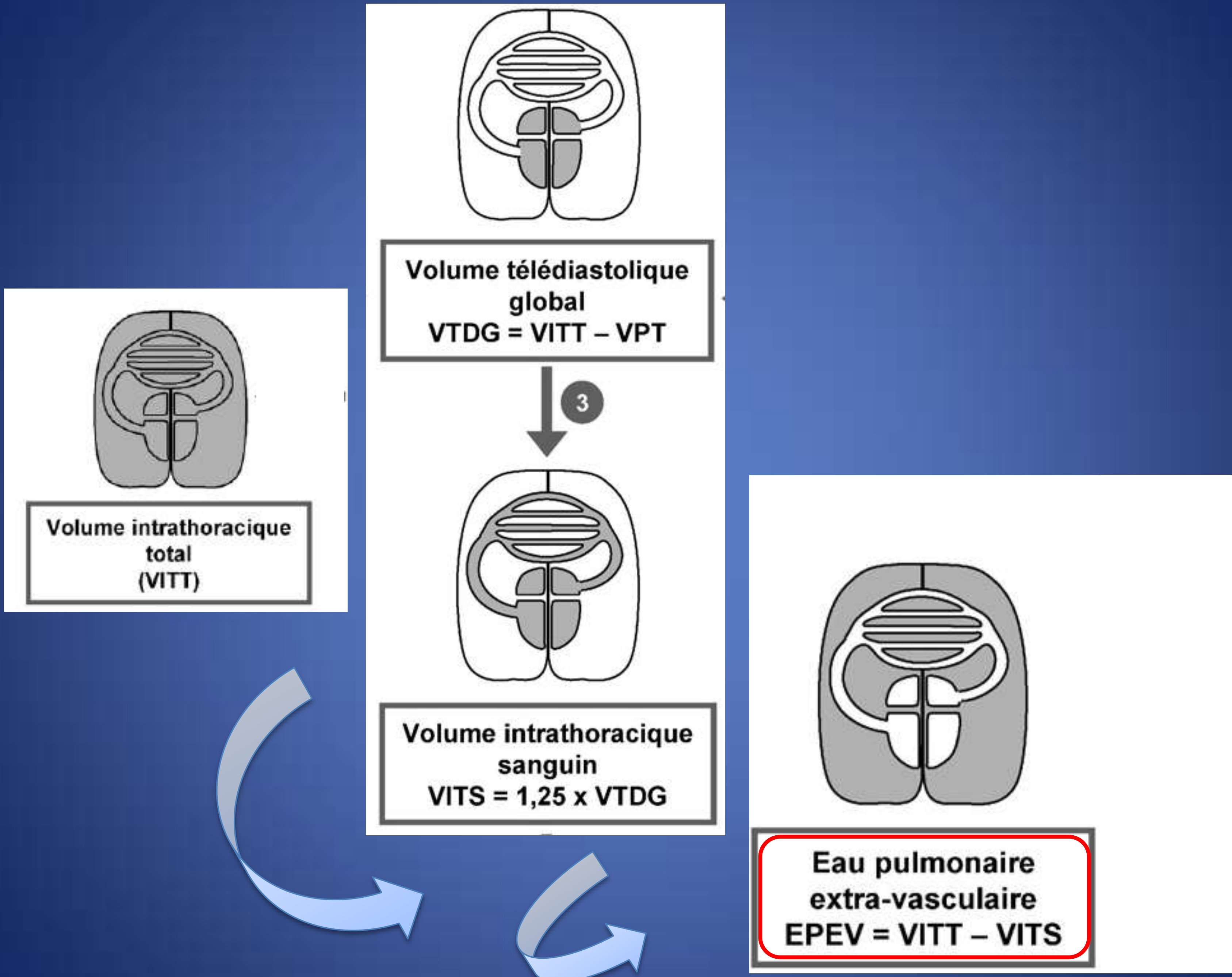




Central venous catheter
Injectate-temperature sensor housing PV4046 (included PV8115)
Injectate-temperature sensor cable M1646A (Philips)* PC80109 (PULSION)*
PULSION PMK-206
Temperature interface cable M1643A (Philips) PC80150 (PULSION)
PULSIOCATH Arterial Thermodilution Catheter e.g. PV2015L20
PULSION disposable pressure transducer PiCCO Monitoring Kit PV8115
* Cables are identical
DRUCK

Thermodiluation trans-pulmonaire



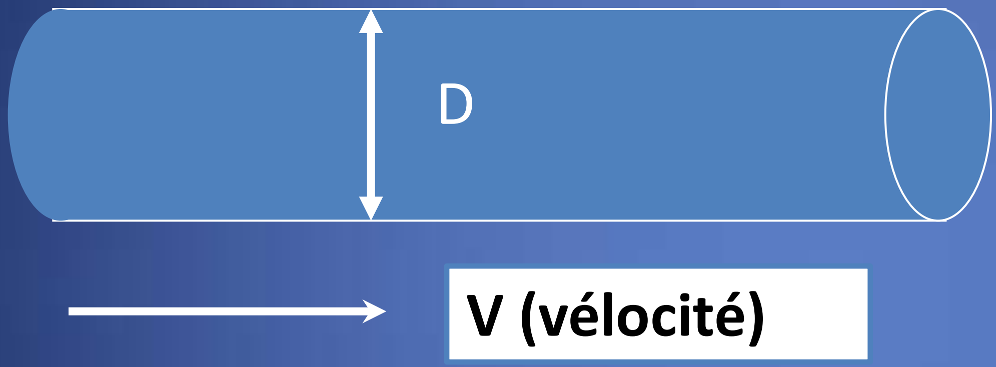

Volume intrathoracique total (VITT)
Volume télédiastolique global
VTDG = VITT – VPT
3
Volume intrathoracique sanguin
VITS = 1,25 x VTDG
Eau pulmonaire extra-vasculaire
EPEV = VITT – VITS

Vers une réanimation moins invasive…

Echographie cardiaque

- Evaluation du débit cardiaque.
- Evaluation de la fonction diastolique du VG.
- Identification de l'étiologie du choc en cas de choc cardiogénique.
- Examen reproductible au lit du malade mais opérateur dépendant.
- Monitorage discontinu.

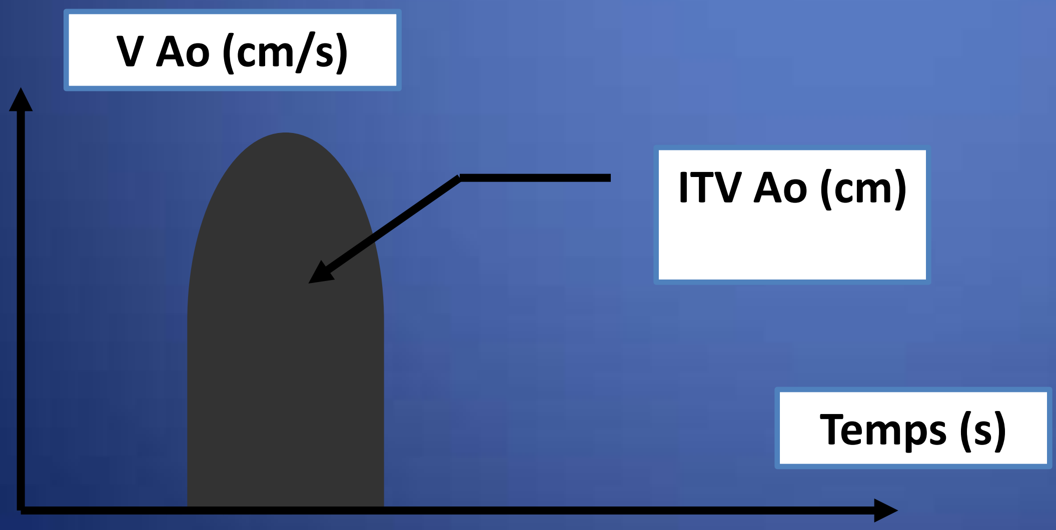
Principe du doppler oesophagien



$S = \pi D^2 / 4$

VES = ITV x S

DC = VES x F



Silva and Teboul *Critical Care* 2011, 15:1004
http://ccforum.com/content/15/6/1004

CRITICAL CARE

COMMENTARY

Defining the adequate arterial pressure target during septic shock: not a 'micro' issue but the microcirculation can help

Serena Silva[1] and Jean-Louis Teboul*[1,2]

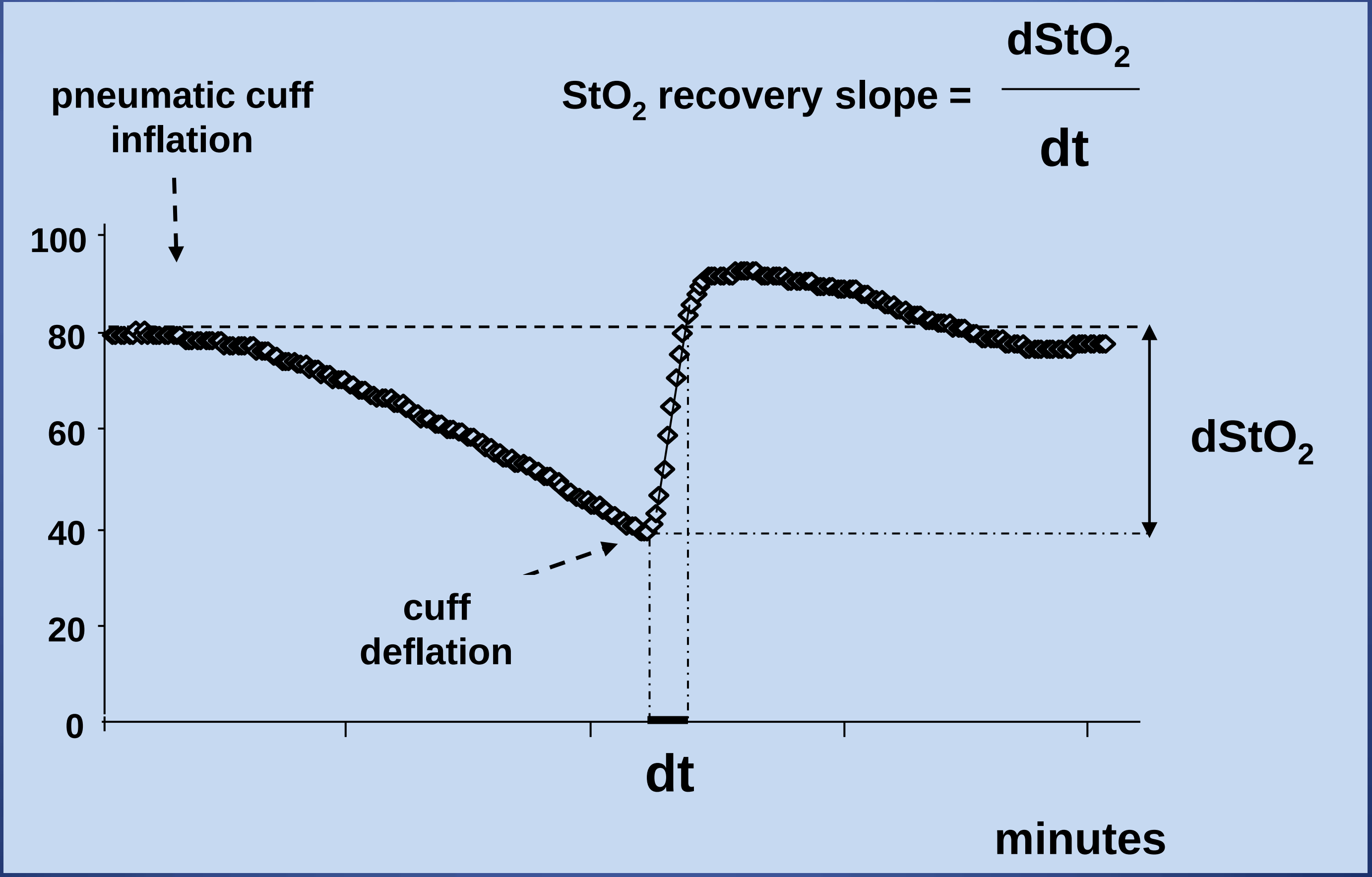
Plusieurs techniques disponibles :

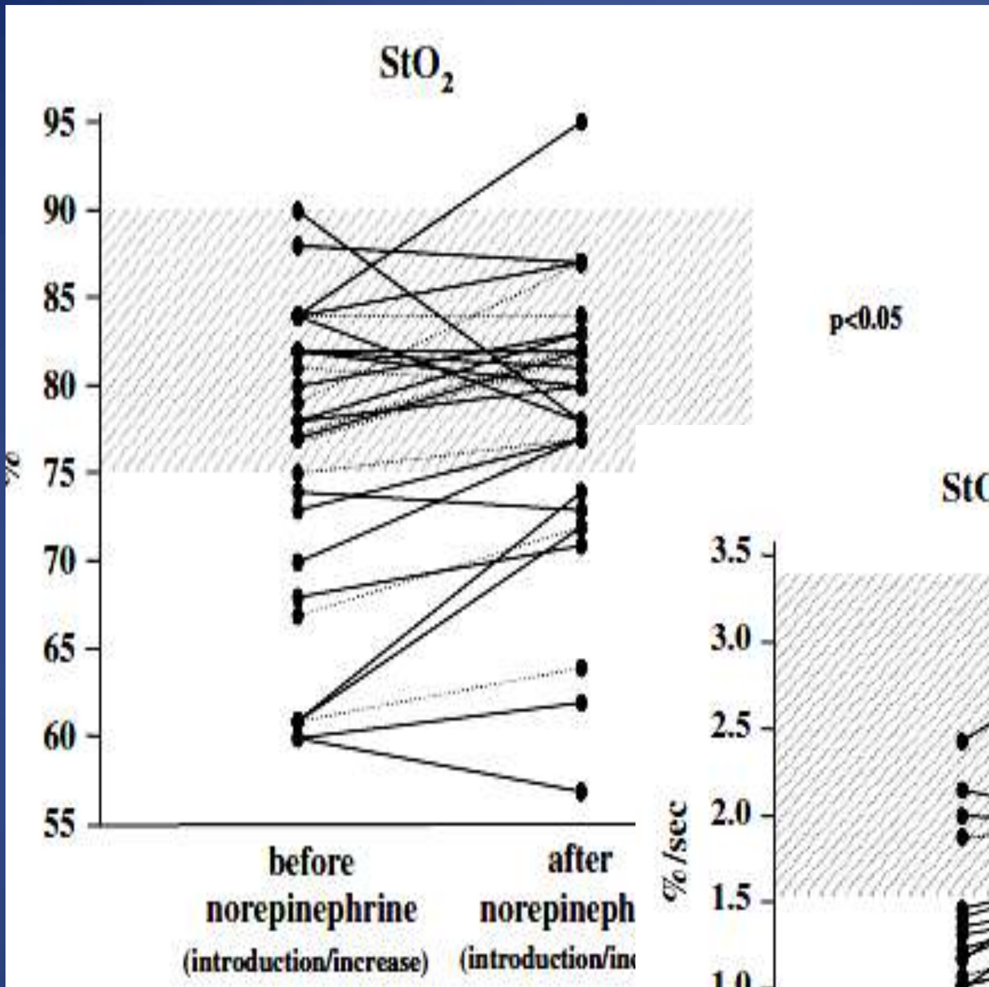
- **La NIRS (Near infra red spectroscopy).**
- **L'OPS (orthogonal polarization spectroscopy).**
- **La tonométrie gastrique.**
- **Le gradient artério-veineux en CO2**
- **….**

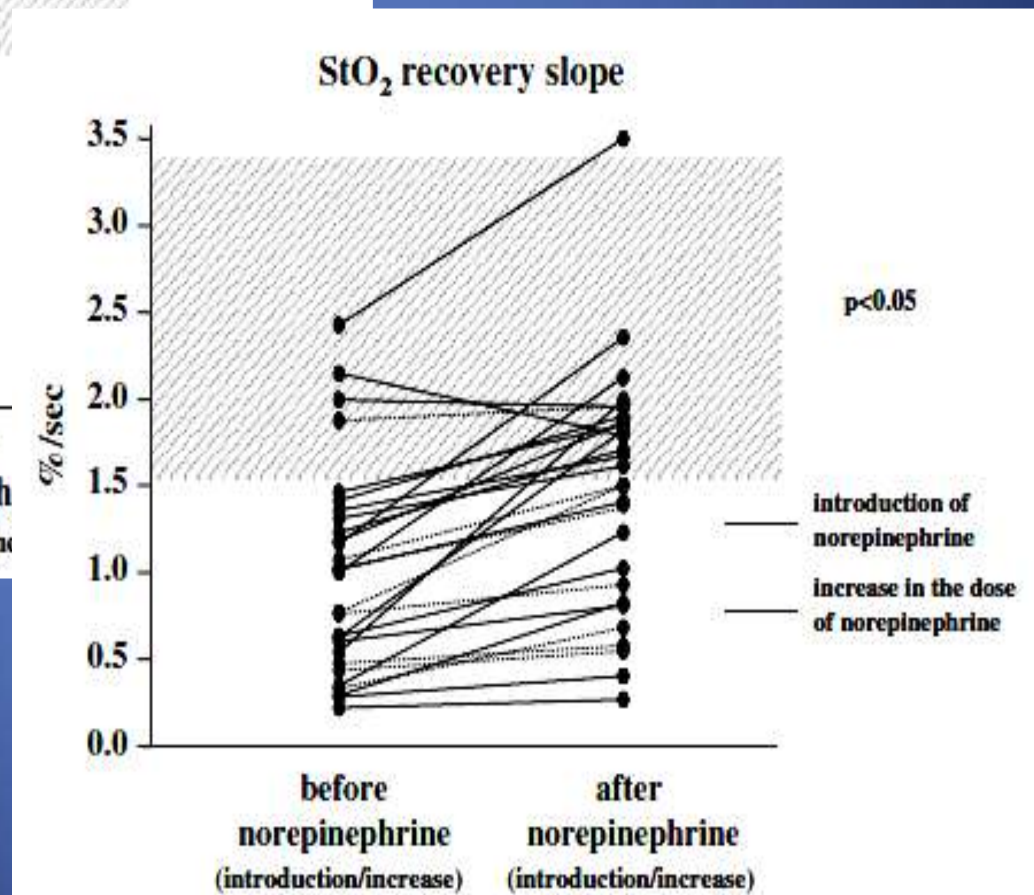
Jean-François Georger
Olfa Hamzaoui
Anis Chaari
Julien Maizel
Christian Richard
Jean-Louis Teboul

Restoring arterial pressure with norepinephrine improves muscle tissue oxygenation assessed by near-infrared spectroscopy in severely hypotensive septic patients

Intensive Care Med (2010) 36:1882–1889




StO2
95
90
85
80
75
70
65
60
55
%
p<0.05
before
norepinephrine
(introduction/increase)
after
norepineph
(introduction/in


StO2 recovery slope
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
% /sec
p<0.05
introduction of
norepinephrine
increase in the dose
of norepinephrine
before
norepinephrine
(introduction/increase)
after
norepinephrine
(introduction/increase)

RESEARCH Open Access

Effects of changes in arterial pressure on organ perfusion during septic shock

CRITICAL CARE

Aurélie Thooft, Raphaël Favory, Diamantino Ribeiro Salgado, Fabio S Taccone, Katia Donadello, Daniel De Backer, Jacques Creteur and Jean-Louis Vincent*

Thooft *et al. Critical Care* 2011, **15**:R222

Table 2 Norepinephrine doses and hemodynamic variables

	65 mm Hg	75 mm Hg	85 mm Hg	65 mm Hg
Norepinephrine, μg/minute	17.3 (5.9-28.6)	24.5 (9.5-39.5)[a]	32.7 (14.0-51.4)[a]	22.4 (11.0-33.8)
Mean arterial pressure, mm Hg	66.0 (65.1-66.8)	75.9 (73.5-78.3)[a]	86.3 (84.3-88.4)[a]	66.2 (65.1-67.3)
Heart rate, beats per minute	93.5 (83.9-103.1)	91.4 (81.4-101.5)	92.8 (82.1-103.6)	94.2 (81.7-106.7)
Cardiac output, liters per minute	6.1 (5.4-6.8)	6.5 (5.7-7.3)	6.7 (5.9-7.6)[a]	6.1 (5.4-6.8)
Mean pulmonary arterial pressure, mm Hg	29 (24.9-33.1)	30.3 (26-34.7)	32.2 (27.9-36.5)[a]	29.4 (24.8-34.0)
Pulmonary artery occlusion pressure, mm Hg	15.3 (12.7-18)	15.4 (12.7-18.2)	16.1 (13.5-18.6)	14.6 (12.2-17.1)
Central venous pressure, mm Hg	12.0 (9.8-14.3)	12.8 (10.3-15.2)	13.4 (11.1-15.7)[a]	12.4 (10.3-14.5)
Systemic vascular resistance, dyne/second per cm^{-5}	716 (647-786)	803 (711-896)[a]	902 (793-1,010)[a]	726 (645-806)
Pulmonary vascular resistance, dyne/second per cm^{-5}	181 (141-222)	188 (141-234)	197 (150-244)	184 (134-234)
Change in pulse pressure, percentage	2 (1.5-4.5)	2.5 (1-8)	1.5 (0-4)	4 (3-7)

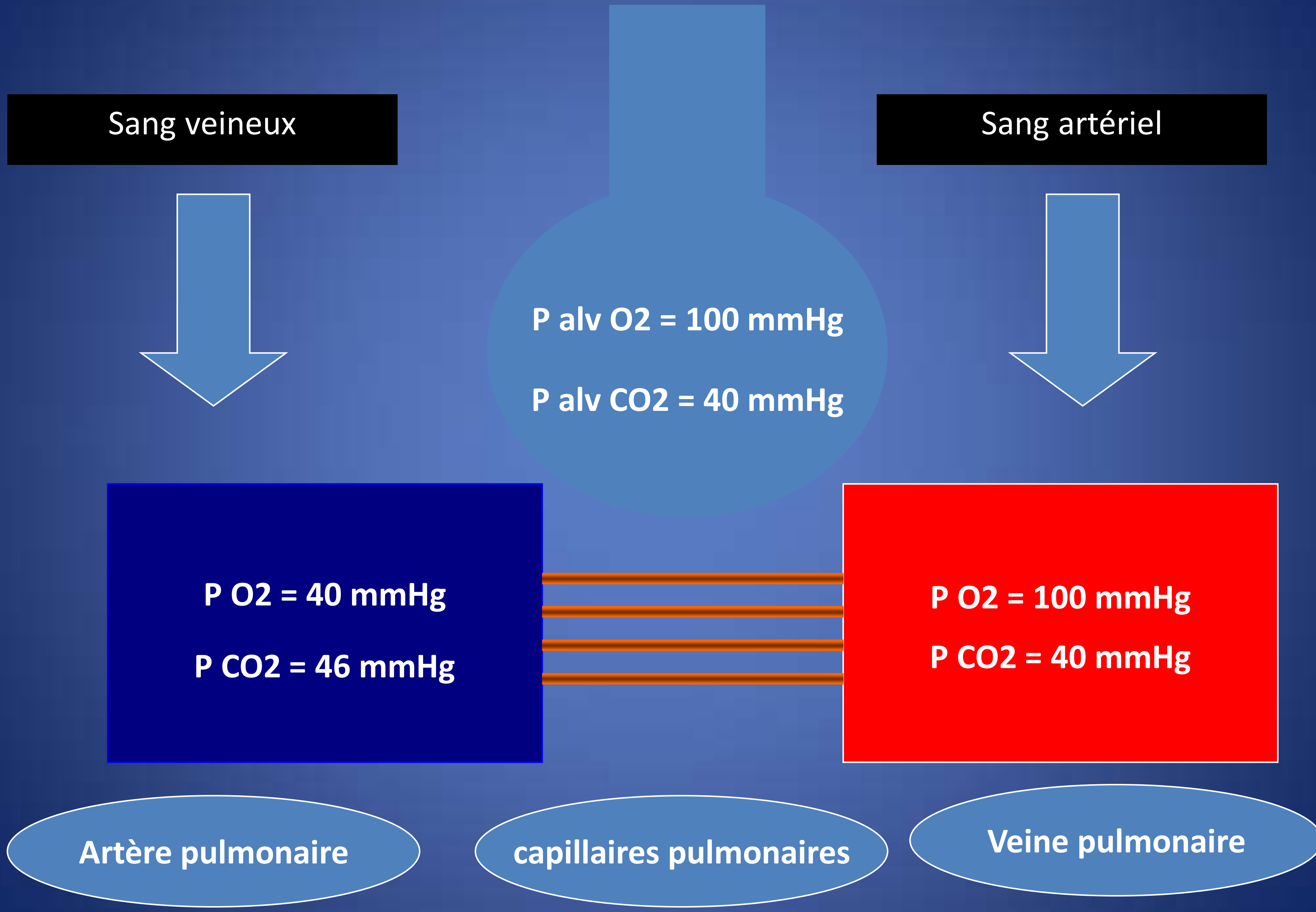
[a] *P* <0.05 versus baseline.

Table 4 Near-infrared spectroscopy and sidestream dark field variables

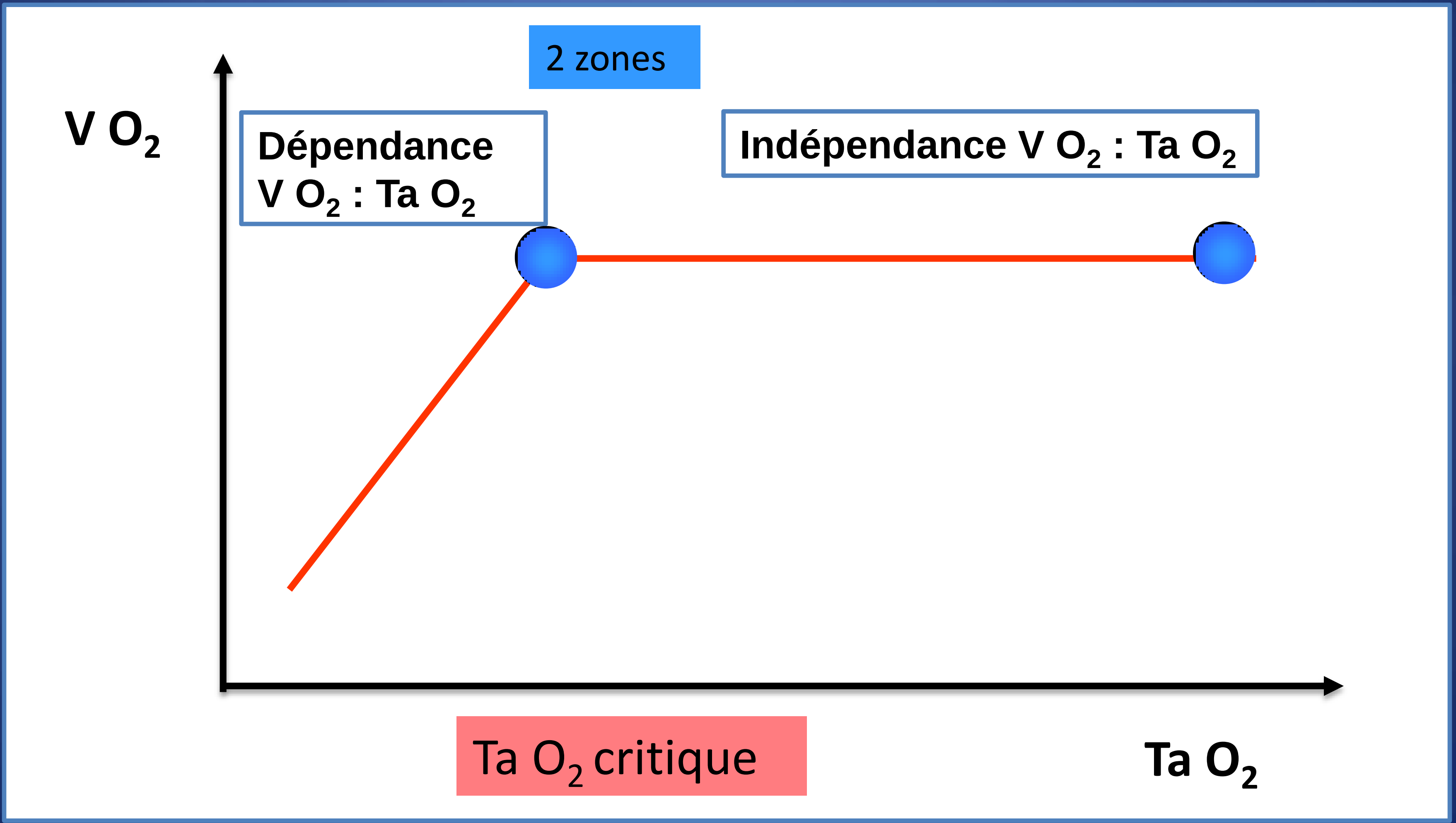
	65 mm Hg	75 mm Hg	85 mm Hg	65 mm Hg
NIRS variables				
StO_2 baseline, percentage	82.5 (79.0-85.9)	81.0 (77.0-85.0)	81.2 (77.6-84.7)	77.8 (73.6-82.1)
Descending slope, percentage/minute	−14.8 (−18.0 - −11.6)	−14.5 (−18.9 - −10.0)	−16.4 (−22.0 - −10.9)	−15.7 (−21.9 - −9.4)
$nirVO_2I$, arbitrary units	139 (114-165)	122 (98-146)	153 (109-196)	129 (93-165)
Delta StO_2, percentage	7.4 (5.3-9.5)	8.4 (5.2-11.6)	7.7 (5.4-9.9)	7.4 (5-9.7)
AUC ratio, percentage	0.11 (0.05-0.16)	0.12 (0.09-0.15)	0.10 (0.08-0.14)	0.10 (0.07-0.15)
Ascending slope, percentage/minute	111 (80-141)	172 (115-228)[a]	177 (122-232)[a]	114 (94-134)
SDF variables				
Total vessel density	12.8 (10.5-15.0)	13.2 (11.1-15.3)	14.3 (12.9-15.7)	13.7 (11.0-16.4)
Small vessel density	10.7 (8.5-12.9)	11 (8.5-13.4)	11.6 (10.1-13.1)	11.7 (9.0-14.3)
PVD, vessels/mm	11.0 (8.6-13.3)	12.0 (9.4-14.5)	13.2 (11.9-14.5)[a]	12.1 (9.2-14.9)
Small PVD, vessels/mm	9.1 (6.4-11.9)	9.8 (6.9-12.8)	10.7 (9.0-12.3)	10.3 (7.1-13.5)
All PPV, percentage	85.9 (80.1-91.6)	89.5 (83.7-95.2)	92.6 (89.9-95.3)	87.7 (79.9-95.6)
Large PPV, percentage	95.5 (93.6-97.4)	95.4 (88.8-102.0)	97.5 (95.2-99.7)	89.8 (82.7-96.9)
Small PPV, percentage	83.6 (76.1-91.0)	87.9 (81.8-94.0)	91.1 (87.9-94.3)	86.4 (76.3-96.5)
Microvascular flow index	2.4 (2.2-2.7)	2.7 (2.4-2.9)	2.9 (2.8-2.9)[a]	2.5 (2.2-2.9)

[a]*P* <0.05 versus baseline. AUC, area under the curve; NIRS, near-infrared spectroscopy; $nirVO_2I$, reverse descending slope multiplied by the average tissue hemoglobin index during the first occlusion minute; PPV, proportion of perfused vessels; PVD, perfused vessel density; SDF, sidestream dark field; StO_2, thenar muscle oxygen saturation.

Gradient P(a-v) CO_2



relation TaO2 : VO2



Hypoperfusion tissulaire

↗ gradient en CO_2

Se limiter à la $ScVO_2$ = se limiter au « combustible »

Prêter intérêt au gradient CO_2 = Intérêt au « produit de combustion » (Métabolisme cellulaire)

Conclusion

- Plusieurs techniques de monitorages disponibles.
- Peut-on s'affranchir d'un monitorage hémodynamique ?
- Utiliser le moyen de monitorage le plus approprié à chaque patient.
- Utiliser le monitorage qu'on sait interpréter.
- Avancées importantes dans l'évaluation de la microcirculation.
- Tendance vers un monitorage de moins en moins invasif.