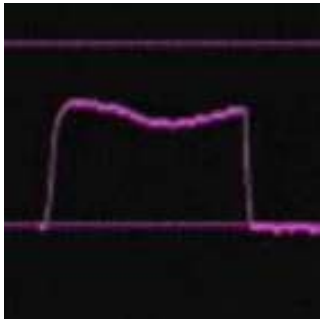


Capnographie

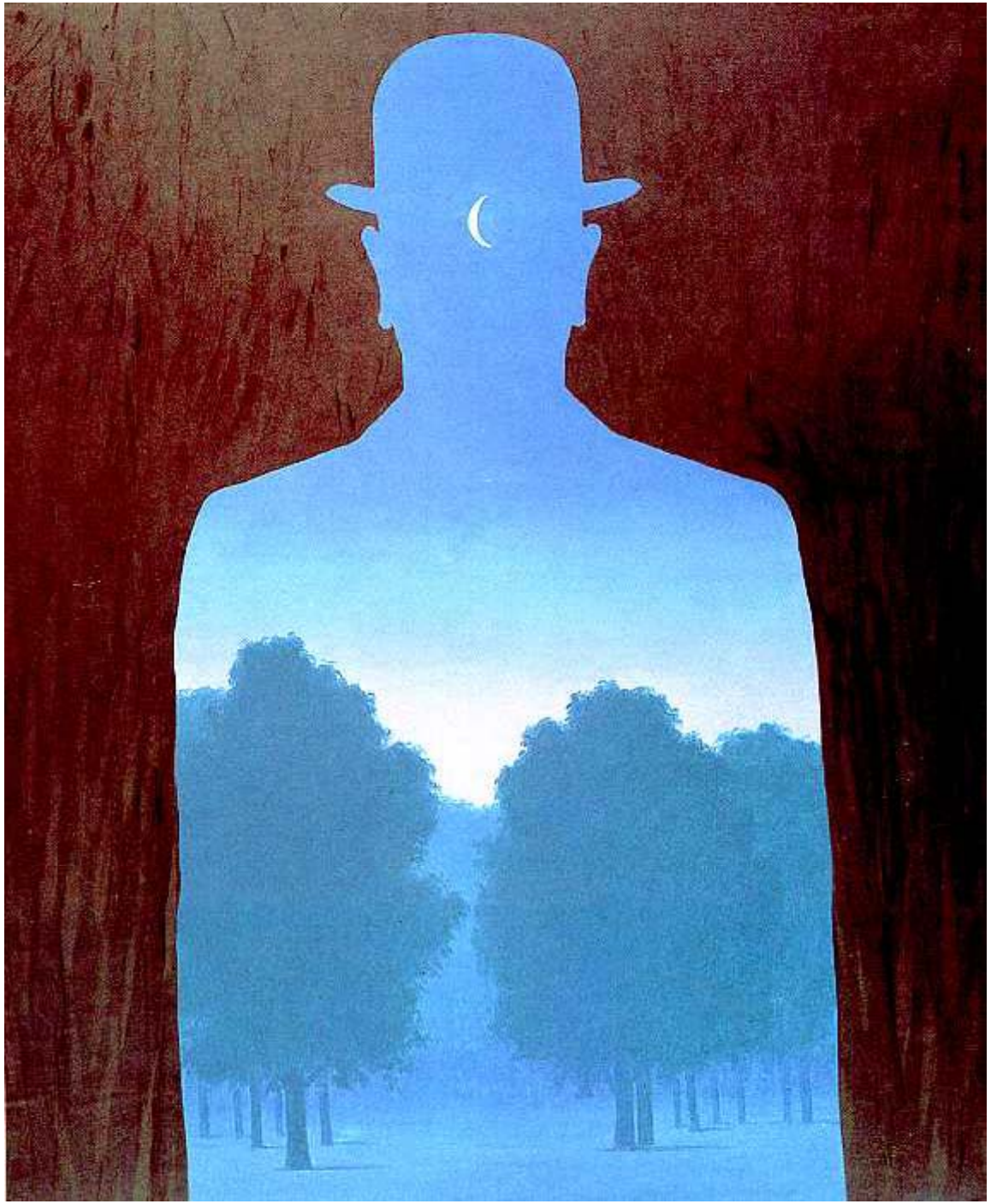
version 5

André Denault MD PhD FRCPC, FASE
ABIM-CCM
Professeur agrégé de clinique

Département d'anesthésiologie
Institut de Cardiologie de Montréal

Service des soins intensifs
Centre Hospitalier Universitaire de Montréal

Décembre 2011

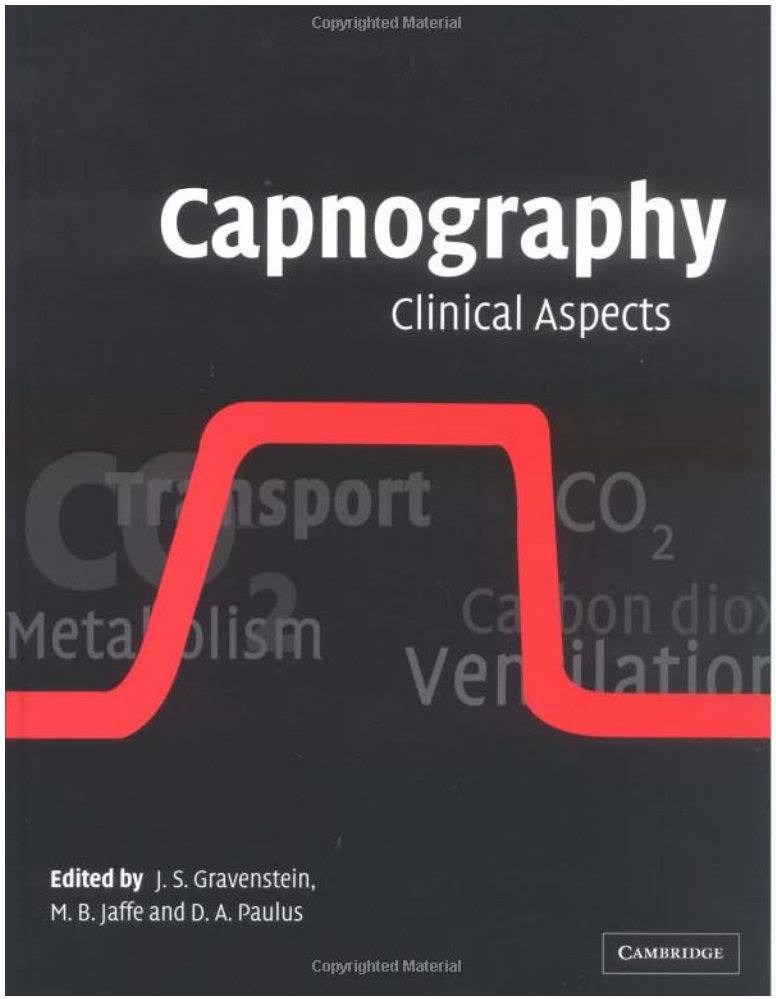


Magritte

Références

Capnography

Edited by J. S. Gravenstein, Michael B. Jaffe, David A. Paulus



ISBN:9780521540346

www.capnography.com

Recipient of "PGA Special Award"

And

"BWPO Clinical Innovation Award"

For Details...

Capnography

A Comprehensive Educational Website
Designed, produced, and maintained by
Bhavani-Shankar Kodali MD
Associate Professor,
Department of Anesthesiology, Brigham and Women's Hospital,
Harvard Medical School, Boston, MA

Site launched August 2001

Edition 5, updated June 2010

'Unrestricted Educational grant'

RESPIRONICS

'Unrestricted Educational gr

Oridio

Capnography.com

It gives me a great pleasure to put forth the revised version of 5th edition of capnography website. Unprecedented encouragement from medical professionals, engineers, technological innovators, and students across the world gave me a sense of satisfaction that long hours spent in the initial designing and deployment of earlier editions of this website did not go futile. It is heartening to state that over 320,000 personnel visit this site annually. During the last few years, this website was able to fulfill its goals and objectives as an avenue to provide dynamic, animated, interactive and up-to-date information on capnography that is easily and readily accessible to everyone without the hassle of passwords. In addition, it is also serving as a forum for active discussion on all issues related to capnography in all medical fields as visualized in the number of e-mails being received on this subject.

A review in the [illegible] October 2001 described this website

Capnographie: standards nord-américain

ASA: “ To ensure adequate ventilation of the patient during all anesthetics … every patients shall have the adequacy of ventilation continually evaluated“

AHA, Am Coll Emer Phys, ACLS: Capnography: "standard of care to determine endotracheal tube position in cardiopulmonary resuscitation“

Guide de l’exercice de l’anesthésie (JCA Novembre 2005): Monitorage requis (utilisés sans interruption) d’un capnographe lorsqu’un tube endotrachéal ou un capnographe est inséré’

Aspect médicolégal

"..from a legal point of view, a physician, EMT, or paramedic who do not use a disposable $ETCO_2$ detector in the process of intubation, in the absence of electronic capnography, is not acting as the average reasonable reputable physician….."

Ginsburg (avocat) 1993 Ann Emerg Med (Los Angeles)

Rôle de la capnographie

A: « Airway » ou détecteur du le positionnement du TET

B: « Breathing » ou détecte la présence d'une ventilation, sa fréquence, le type de ventilation, les anomalies V/Q, estime la $PaCO_2$ et la profondeur de l'anesthésie

C: Circulation sanguine pulmonaire et systémique

D: Diagnostique

E: Espérance de survie

Plan

1-Méthodes et système de mesure

2-Physiologie du CO_2

3-Courbes de CO_2

4-CO_2 volumétrique

5-Autres applications

Plan

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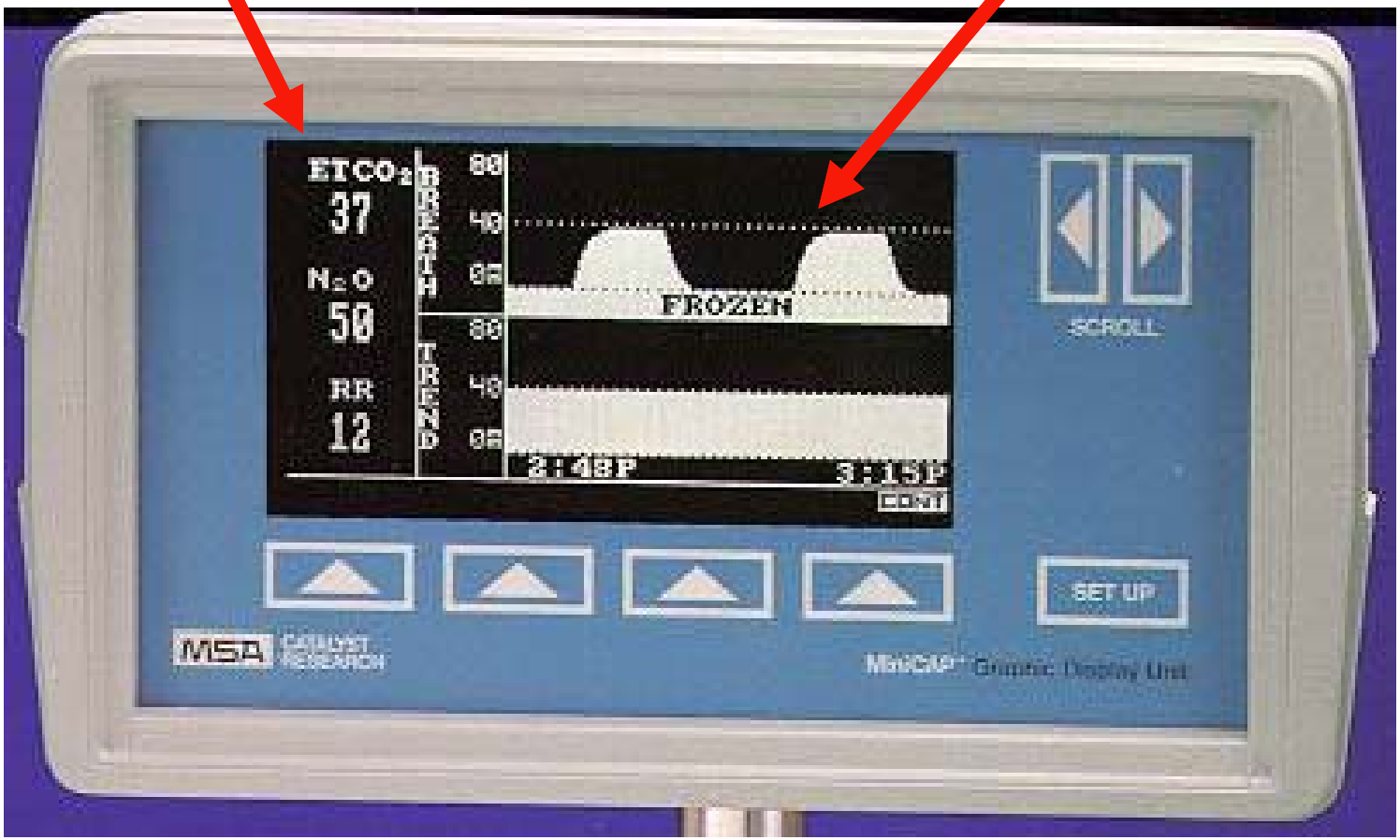
Capnométrie

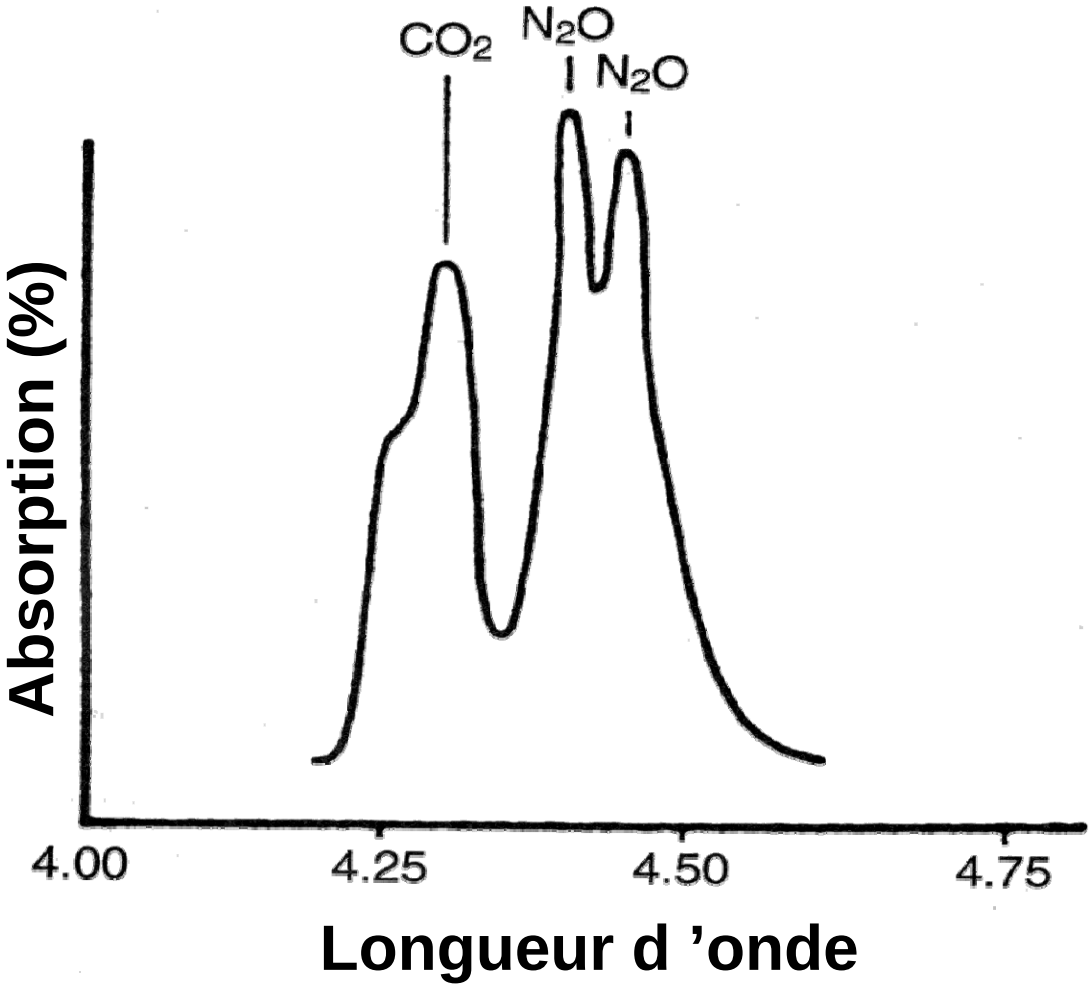
Capnographie



Méthodes de mesure du CO2

- De masse
- Raman
- Infra-rouge
- Photoacoustique

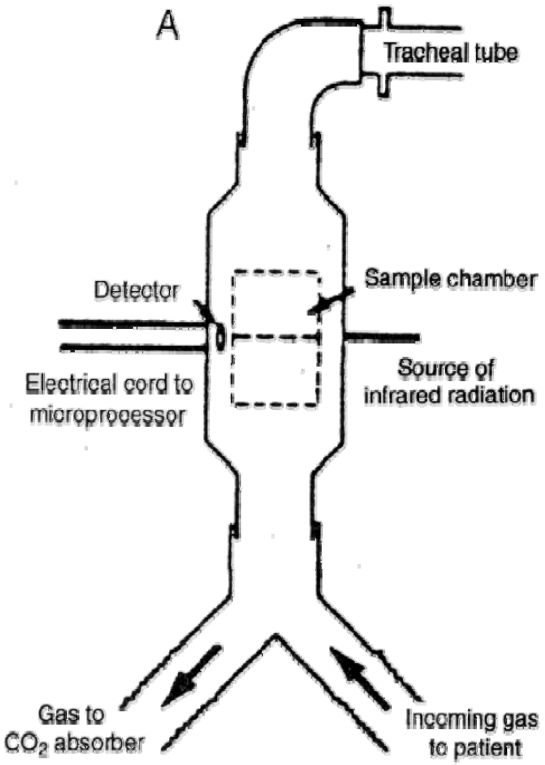
Spectrographie à infra-rouge



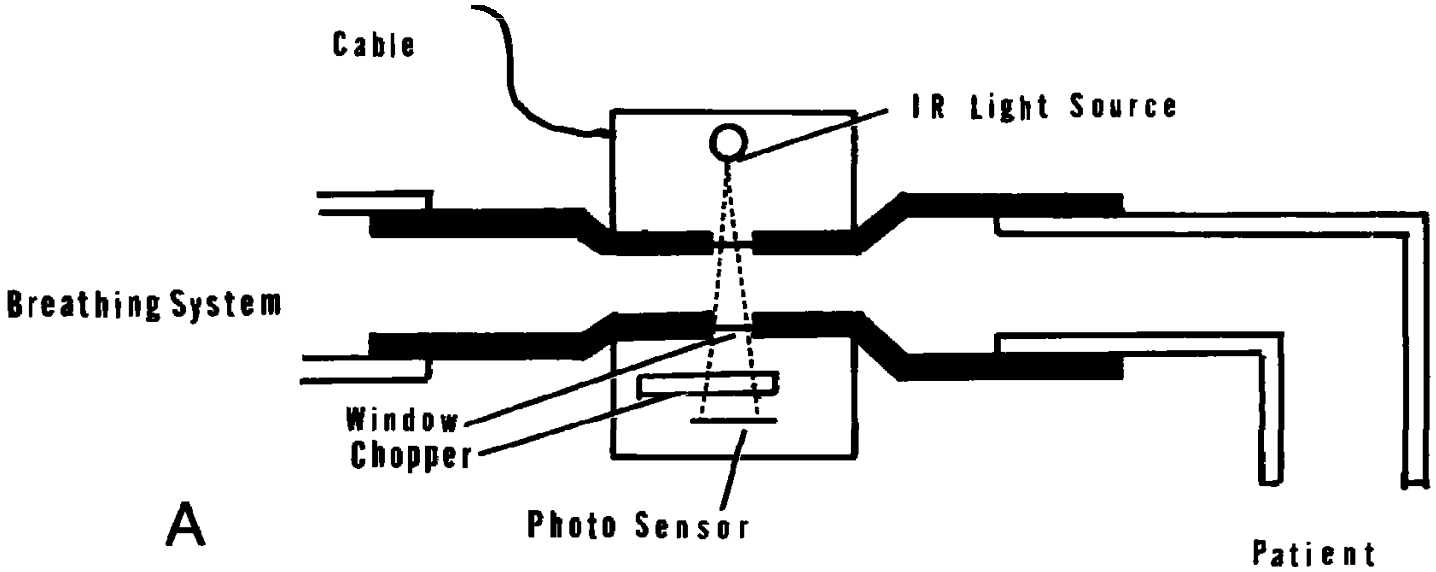
Adapté de Stock Crit Care Clinic 1995

Moniteurs de la mesure du CO_2

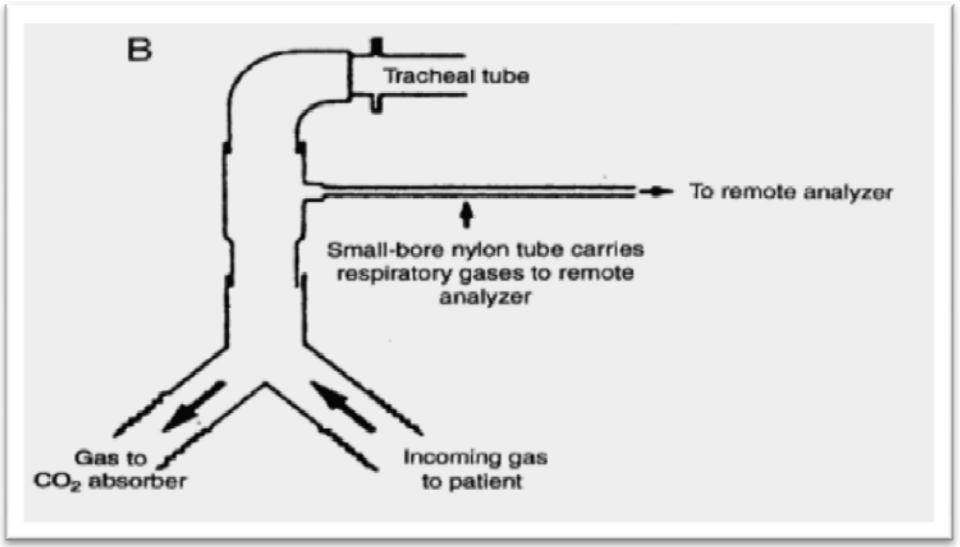
Échantillonage central



Échantilonage central



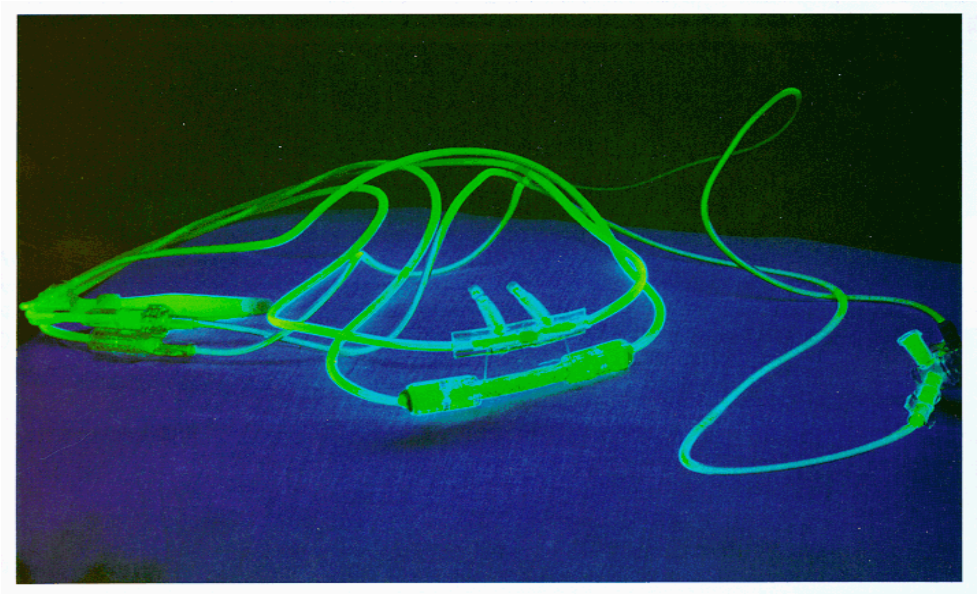
Moniteurs de la mesure du CO_2

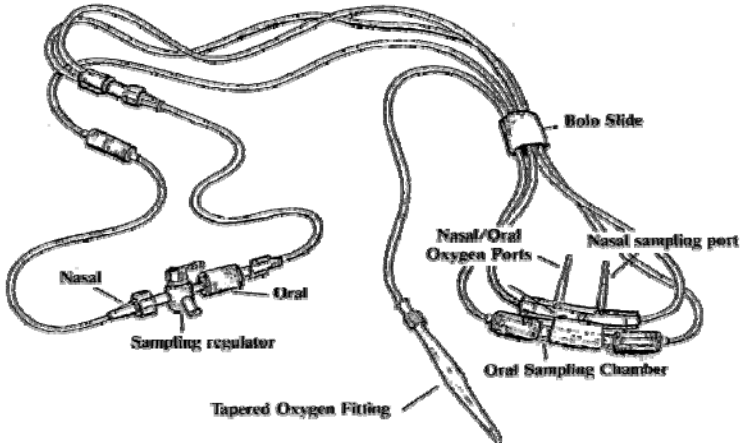


Échantillonage latéral

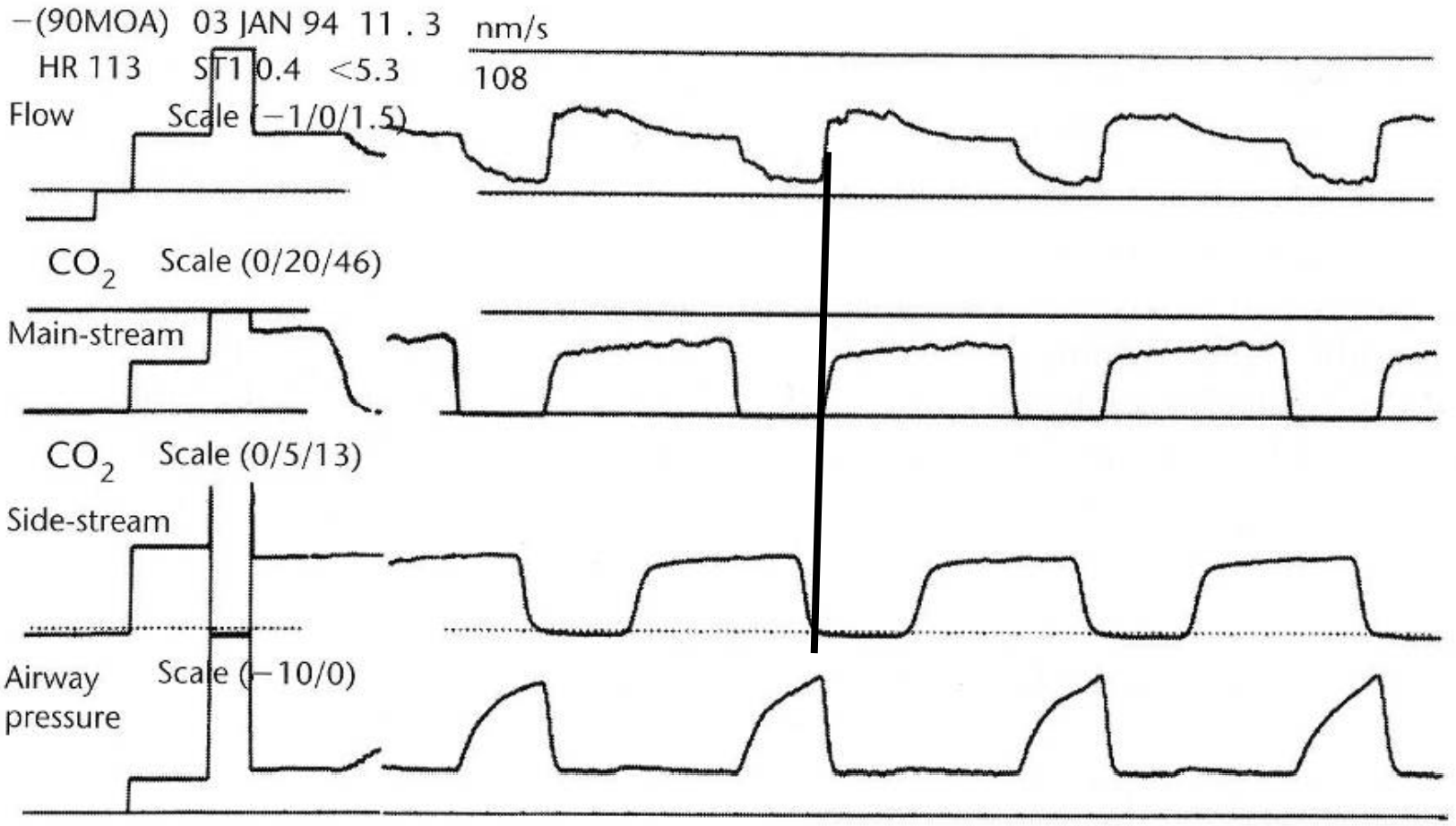
Cuvette

Moniteurs de la mesure du CO_2





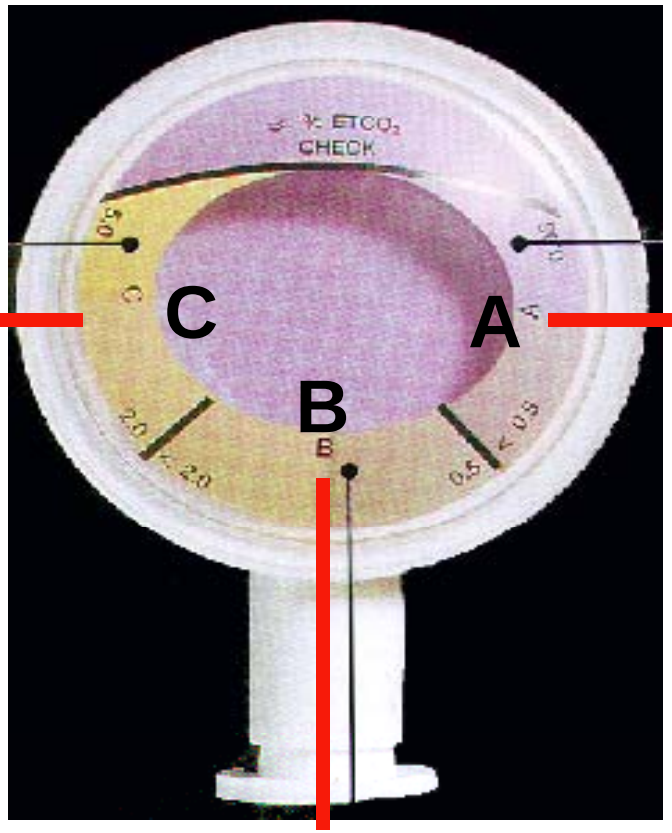
Différence échantillonnage central (main-stream) vs latéral (side-stream)



Moniteurs de la mesure du CO_2

	Type d'échantillonage	
	Latéral (« sidestream »)	Central (« mainstream »)
Délai	+	-
Fuites	+	-
Déconnection	++	+
Circuit fermé	-	+
Obstruction	+	-
Analyse multiple gaz	+	-
Bris du capteur	rare	+
Non-intubé	+	difficile

Détecteur chimique de CO_2



Plan

1-Méthodes et système de mesure

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3-Courbes de CO_2

4-CO_2 volumétrique

5-Autres applications

Déterminants de la $PaCO_2$

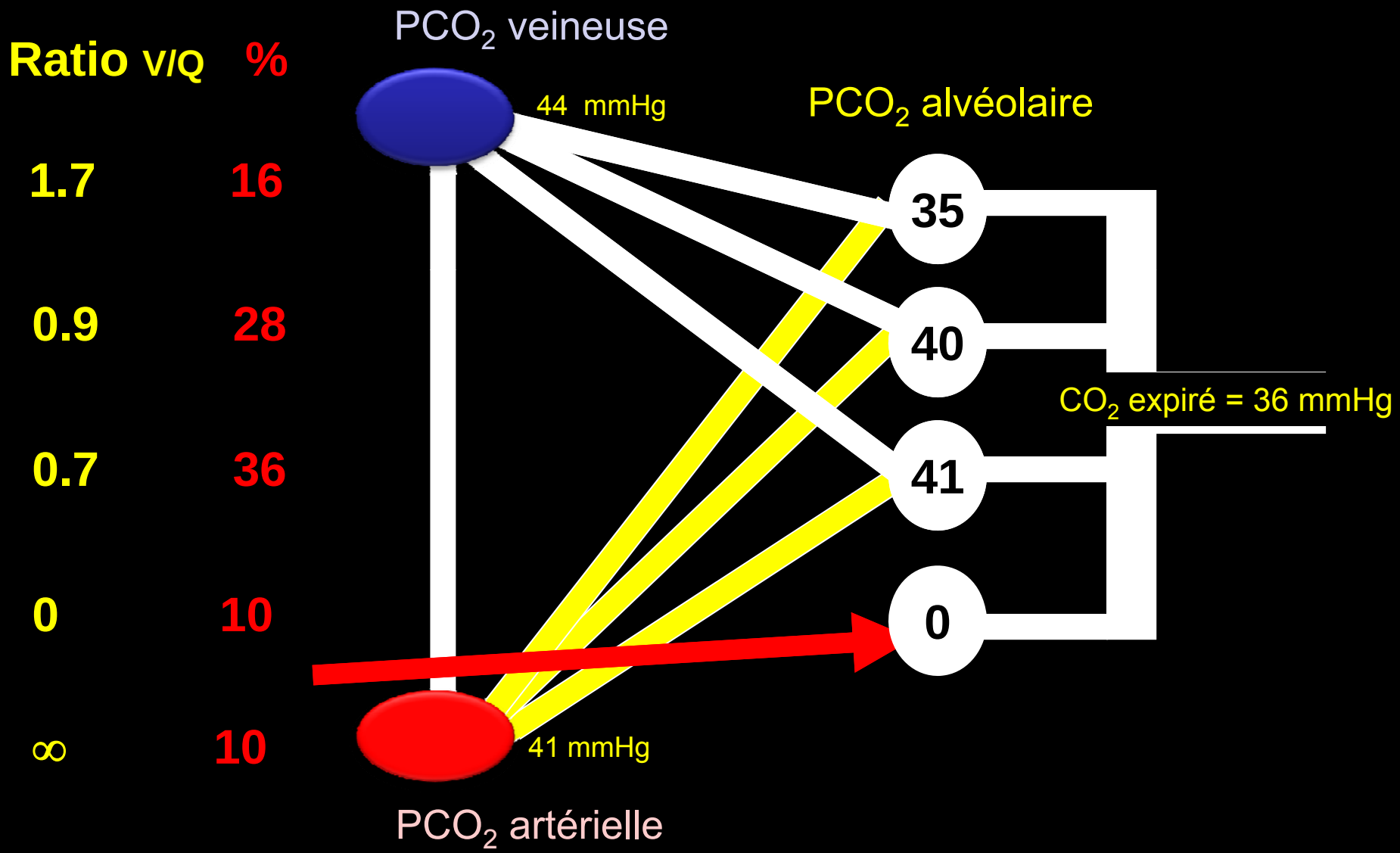
$$PaCO_2 = Pb \times \left(\frac{\text{Production en } CO_2}{\text{Élimination de } CO_2} + FiCO_2 \right)$$

$$PaCO_2 = \frac{\text{Production en } CO_2}{\text{Élimination de } CO_2}$$

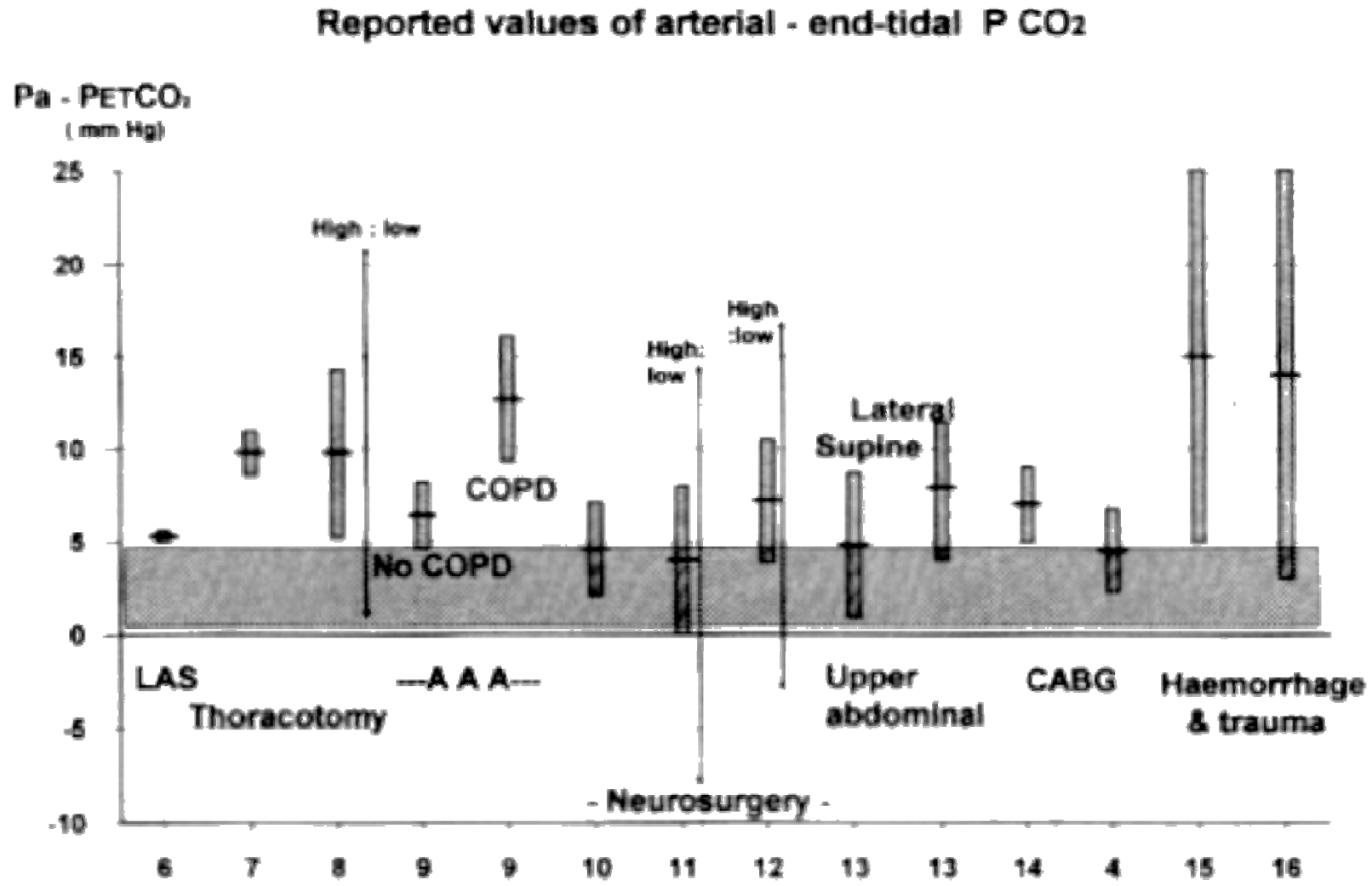
$$PaCO_2 = \frac{VCO_2}{\text{Ventilation (totale - espace mort)}}$$

$$PaCO_2 = \frac{VCO_2}{Vt \times FR \, (1 - Vd/Vt)}$$

Physiologie CO_2: Anomalies ventilation/perfusion



Différence $PaCO_2$ et CO_2 expiré



Wahba RWM. Can J Anesth 1996 :862-6

Gaz artériel et veineux

«(peripheral) venous pH, PCO2, bicarbonate and saturation is of little value in predicting the precise level in arterial blood »

R.N. Sutton et al

Lancet 1967;2:748-51

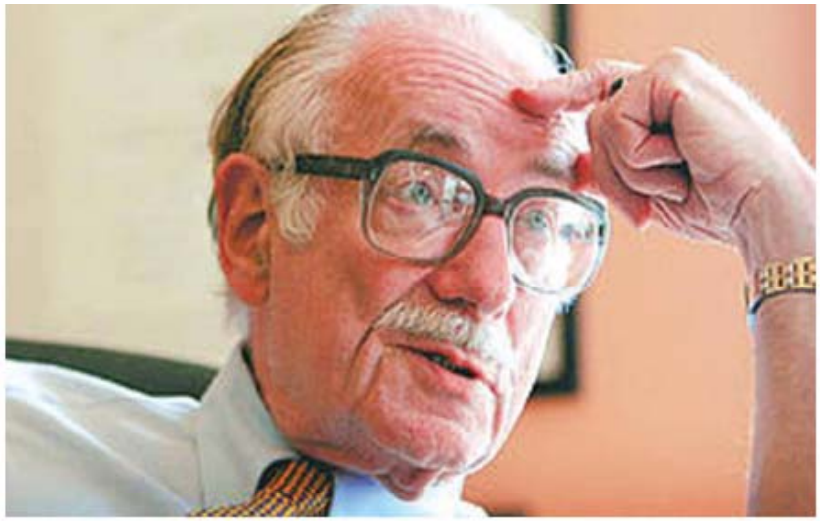
Vincent *Critical Care* 2011, **15**:192
http://ccforum.com/content/15/5/192

CRITICAL CARE

EDITORIAL

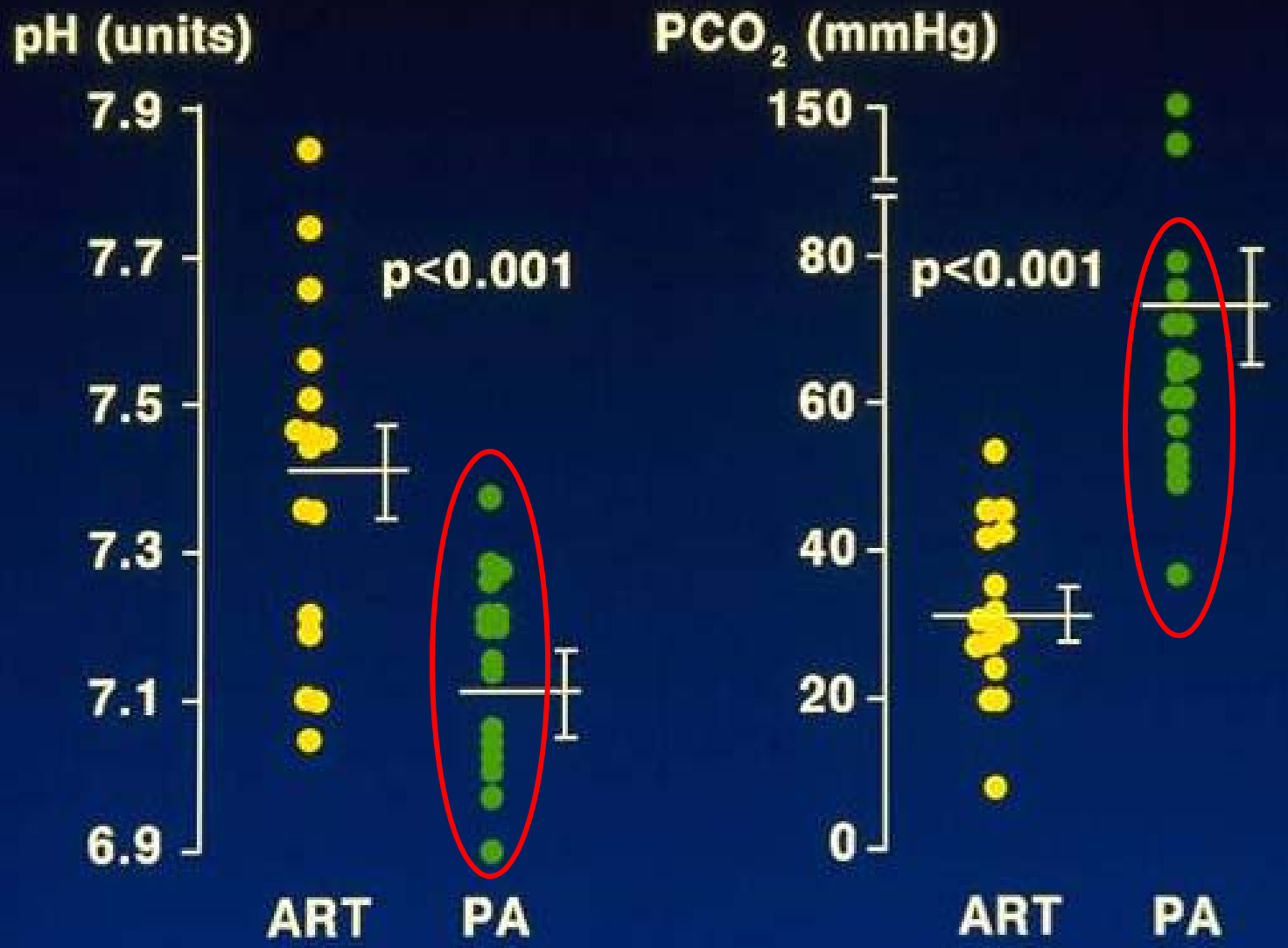
Obituary: Dr Max Harry Weil

Jean-Louis Vincent

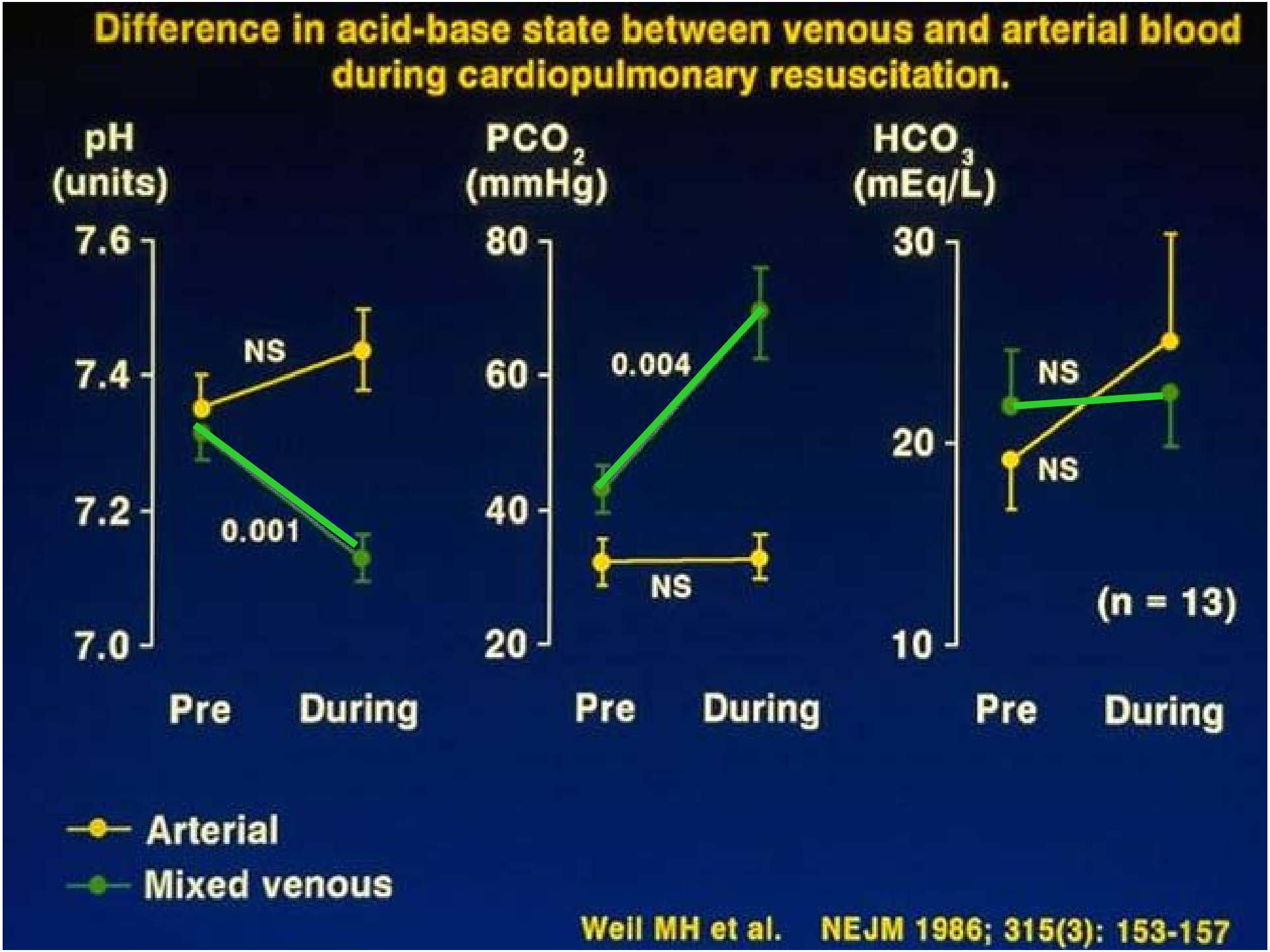


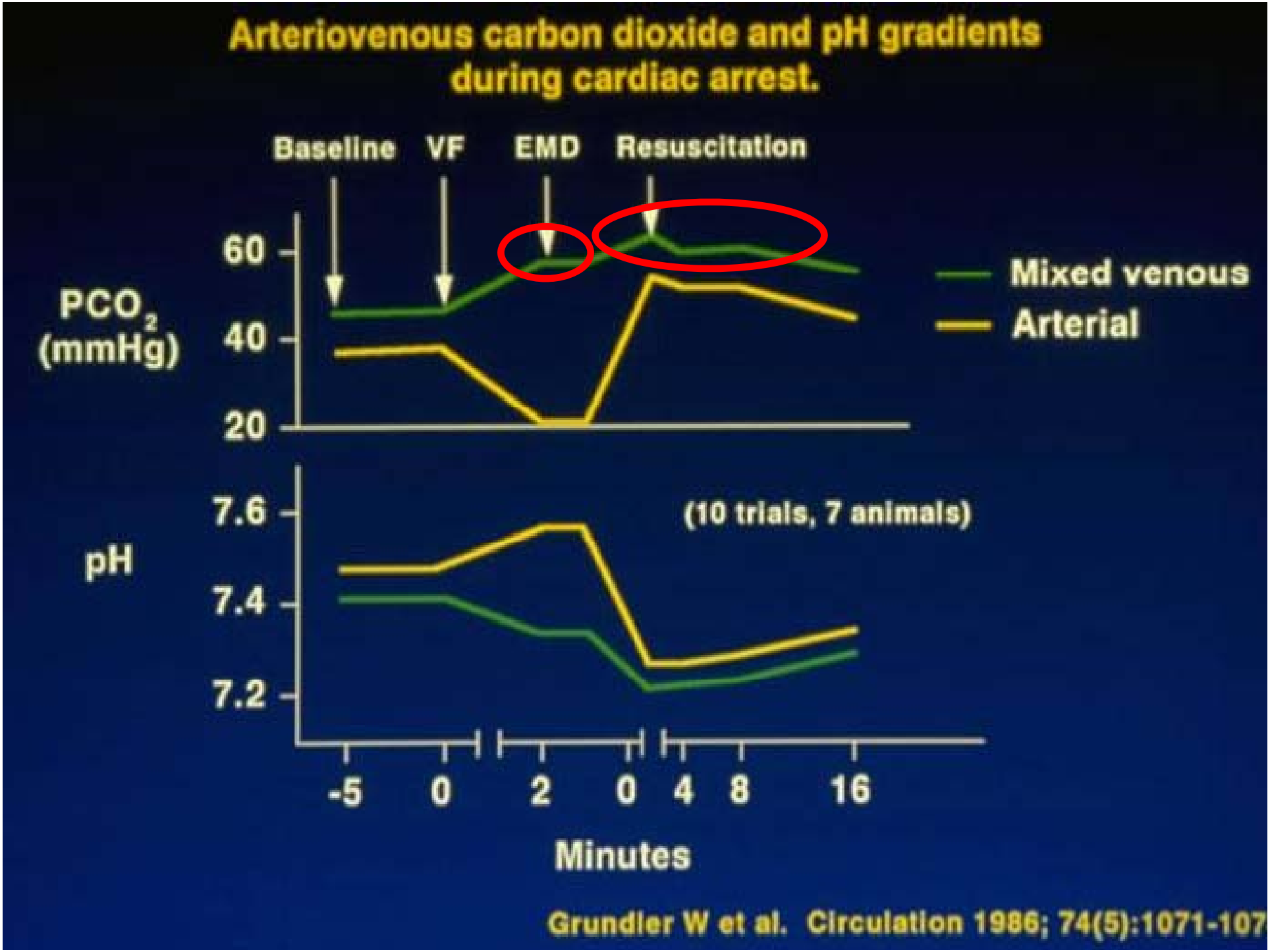
place by Dr Weil, including the use of fluids (he developed the famous fluid challenge technique) and of vasoactive agents. In more recent years, his research focused on the microcirculation and on cardiopulmonary resuscitation, including monitoring techniques (for example, capnometry) and the role of various therapeutic agents. Not

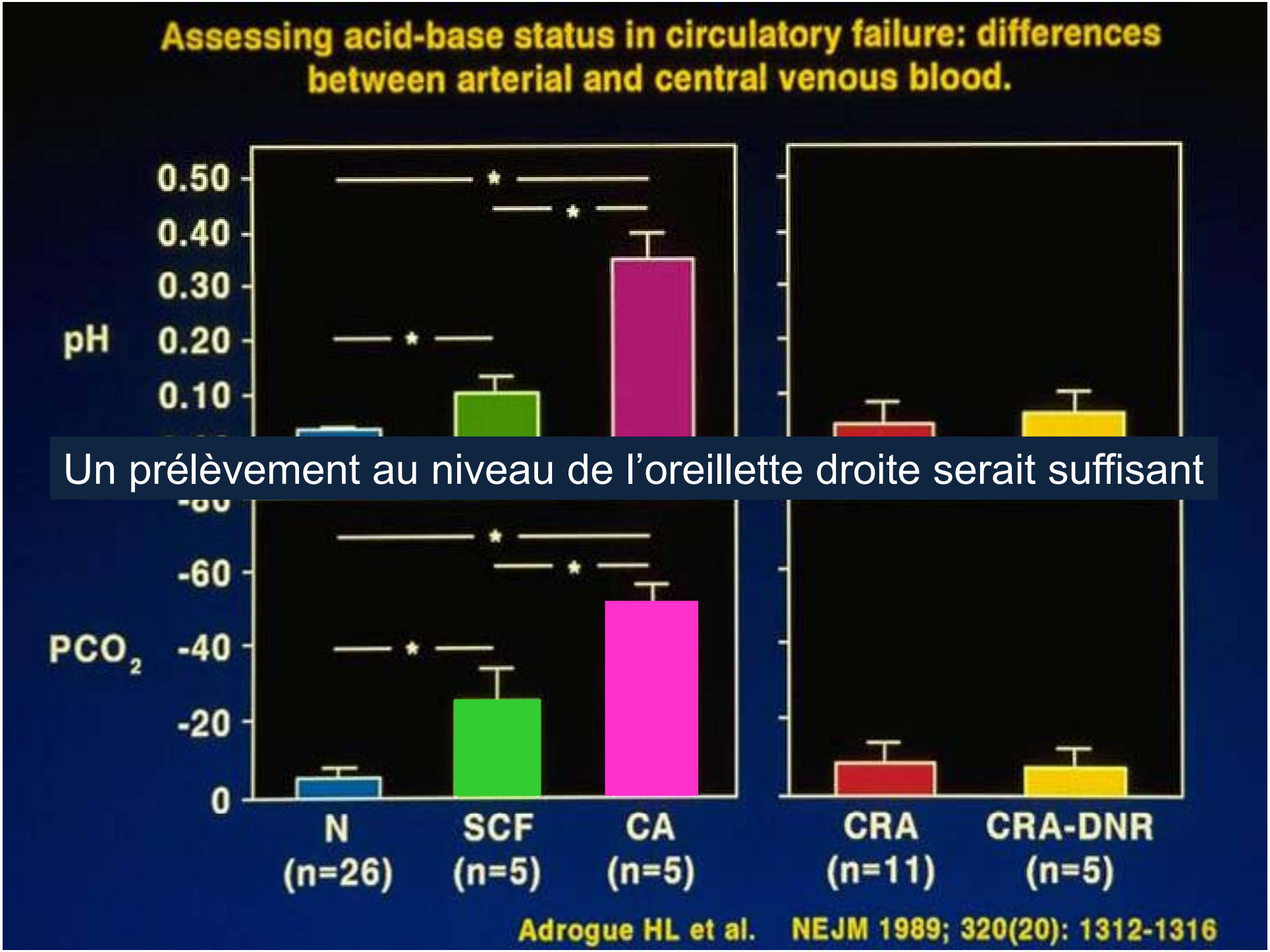
Difference in acid-base state between venous and arterial blood during cardiopulmonary resuscitation.



Weil MH et al. NEJM 1986; 315(3): 153-157


Difference in acid-base state between venous and arterial blood during cardiopulmonary resuscitation.
pH (units)
7.6
7.4
7.2
7.0
NS
0.001
Pre
During
PCO2 (mmHg)
80
60
40
20
0.004
NS
Pre
During
HCO3 (mEq/L)
30
20
10
NS
NS
(n = 13)
Pre
During
Arterial
Mixed venous
Weil MH et al. NEJM 1986; 315(3): 153-157


Arteriovenous carbon dioxide and pH gradients during cardiac arrest.
Baseline
VF
EMD
Resuscitation
60
40
20
PCO2 (mmHg)
Mixed venous
Arterial
7.6
7.4
7.2
pH
(10 trials, 7 animals)
-5
0
2
0
4
8
16
Minutes
Grundler W et al. Circulation 1986; 74(5):1071-107



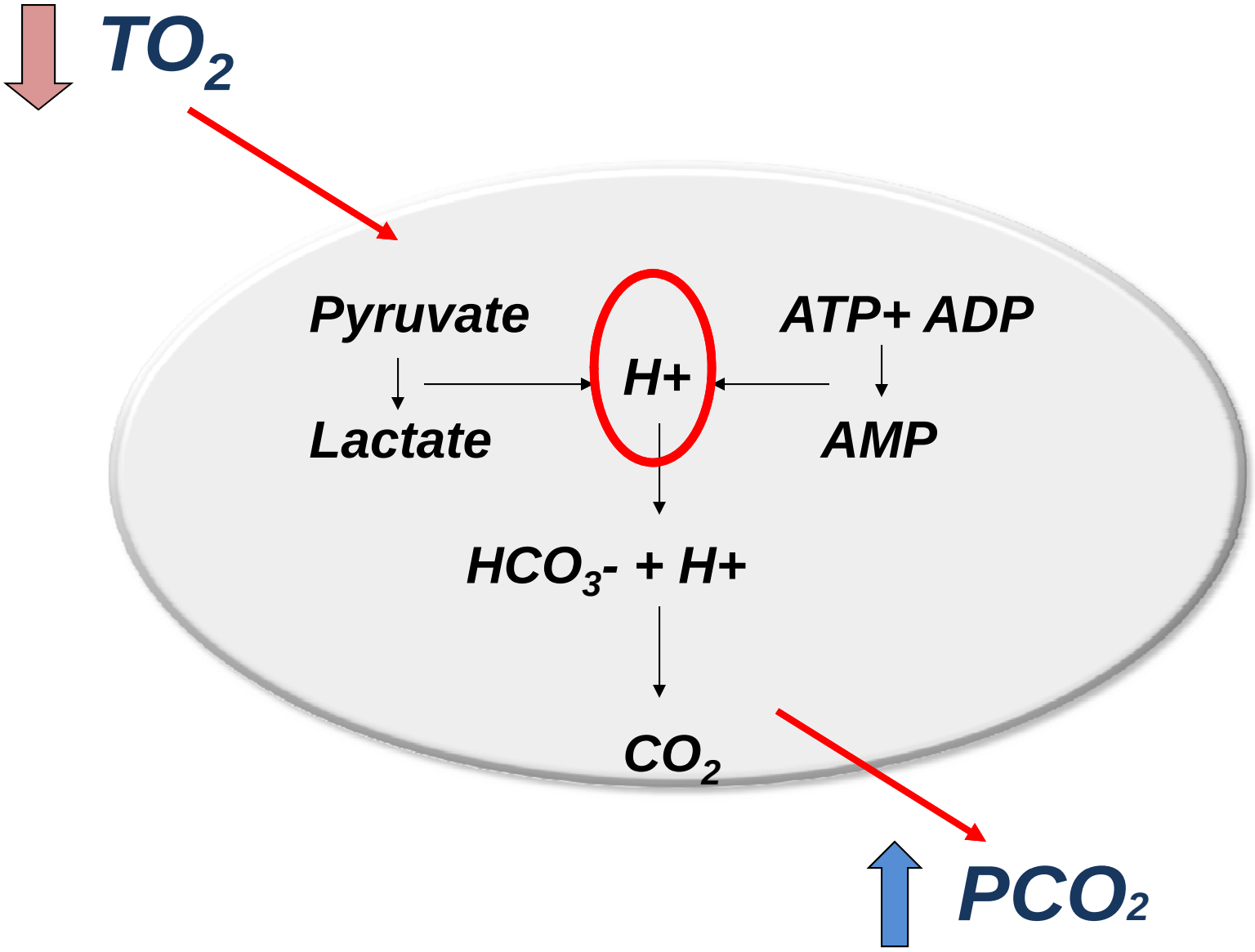
Un prélèvement au niveau de l'oreillette droite serait suffisant

Pourquoi une différence AV en PCO_2?

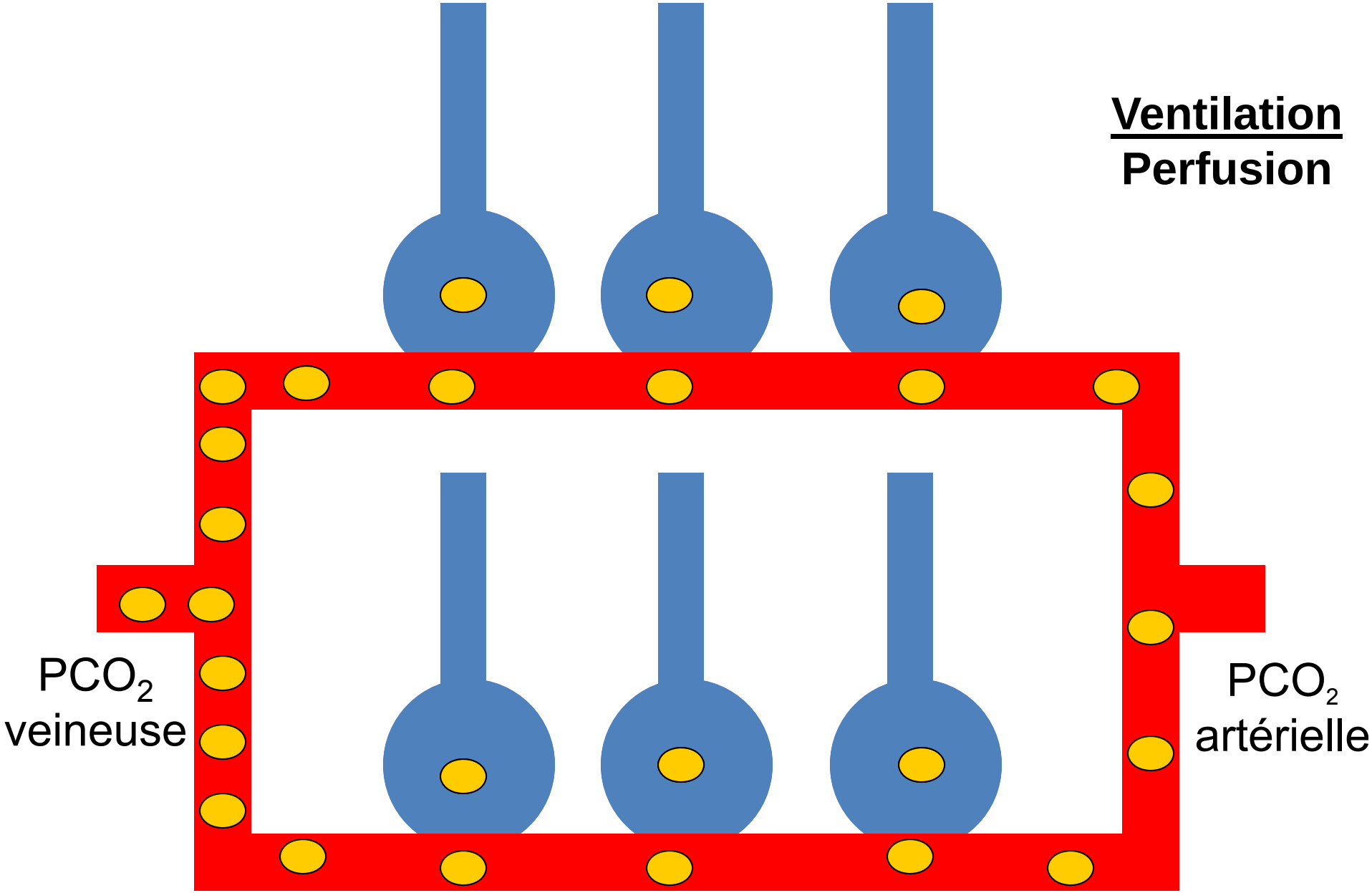
Hypothèses:

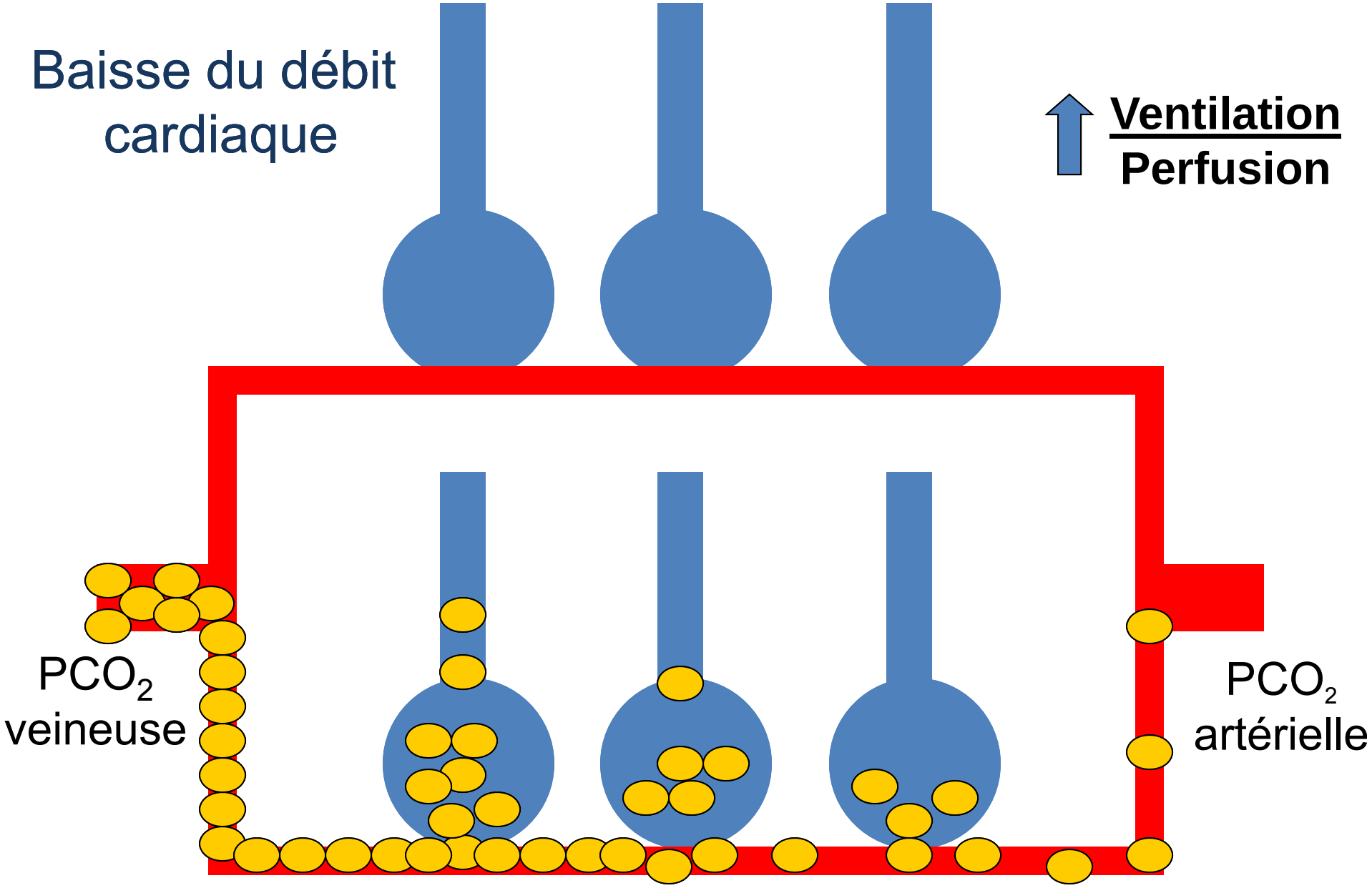
1. Mécanisme circulatoire
2. Production en CO_2 et diffusion par voie anaérobique

Métabolisme anaérobique



Hypothèse circulatoire


Ventilation
Perfusion
PCO2
veineuse
PCO2
artérielle


Baisse du débit cardiaque
Ventilation
Perfusion
PCO2 veineuse
PCO2 artérielle

Wolfgang Peterson 2004

State of the Art

Permissive Hypercapnia
How Permissive Should We Be?

F. FEIHL and C. PERRET

Institut de Physiopathologie Clinique and Service des Soins Intensifs de Médecine, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland

- Effets de l'hypercapnie
  - Métabolique
  - Respiratoire
  - Cardiovasculaire
  - Neurologique

AJRCCM 1994;150:1722-1737

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Anesthesiology 2002; 97:801–6

Hypercapnia Improves Tissue Oxygenation

Ozan Akça, M.D., Anthony G. Doufas, M.D., Ph.D.,† Nobutada Morioka, M.D.,‡ Steve Iscoe, Ph.D.,§ Joseph Fisher, M.D.,‖ Daniel I. Sessler, M.D.#*

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10 healthy volunteers
↑ PCO2 20-30-40-60 mmHg
Measure cardiac index (NICO)
Measure muscle tissue oxygen saturation (Invos 3100)
Measure of cutaneous Doppler velocity (tissue perfusion)
Mesure sub-cutaneous oxygénation (Clark electrode)

Table 2. Global Hemodynamics and Tissue Oxygenation as a Function of Target End-Tidal P_{CO_2}

Target P_{aCO_2} (mmHg)	20	30	40	50	60	p
Cardiac index ($l \cdot min^{-1} \cdot m^{-2}$)	2.7 ± 0.4	2.9 ± 0.4	3.2 ± 0.5	3.6 ± 0.7	3.9 ± 0.2	0.0001
Muscle tissue oxygen saturation (%)*	84.4 ± 7.4	85.8 ± 9.6	86.6 ± 8.1	87.2 ± 8.9	89.0 ± 8.6	0.0004
Laser Doppler flow velocity (U)*	13.6 ± 6.3	13.7 ± 7.7	16.7 ± 6.8	16.2 ± 9.3	17.8 ± 8.5	0.2169
Subcutaneous tissue oxygen tension (mmHg)	51.9 ± 9.9	57.8 ± 11.2	65.2 ± 14.5	74.0 ± 12.3	82.4 ± 18.6	<0.0001

Anesthesiology 2002; 97:801–6

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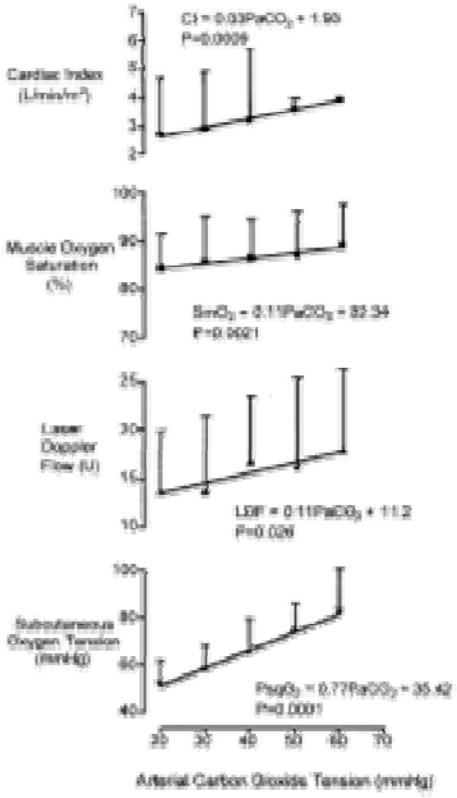

1. This increase in PsqO2 is likely to be clinically important because it is associated with a substantial reduction in the risk of surgical wound infection.
2. These results suggest that maintaining slight hypercapnia is likely to reduce the risk of surgical wound infection.
3. **...previous work indicates that comparable increases in tissue oxygenation reduce the risk of infection from 7 to 8% to 2 to 3%.**

State of the Art

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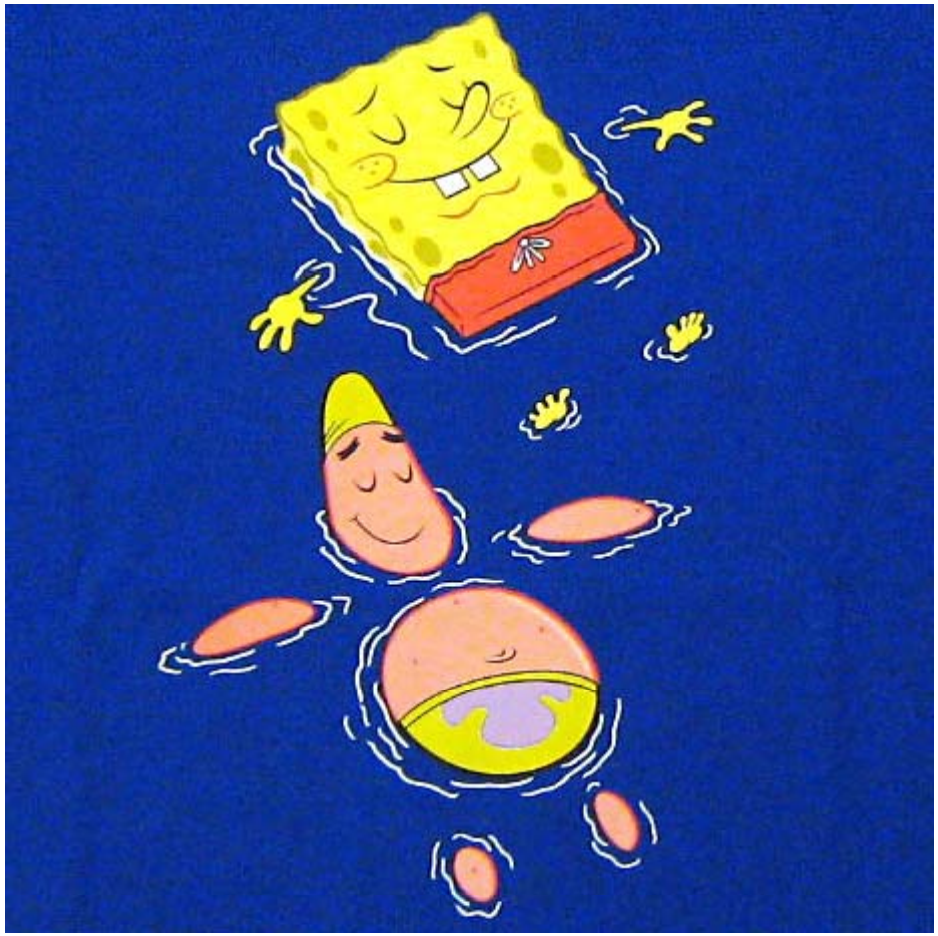
AJRCCM 1994;150:1722-1737

Danger de l’hyperventilation?



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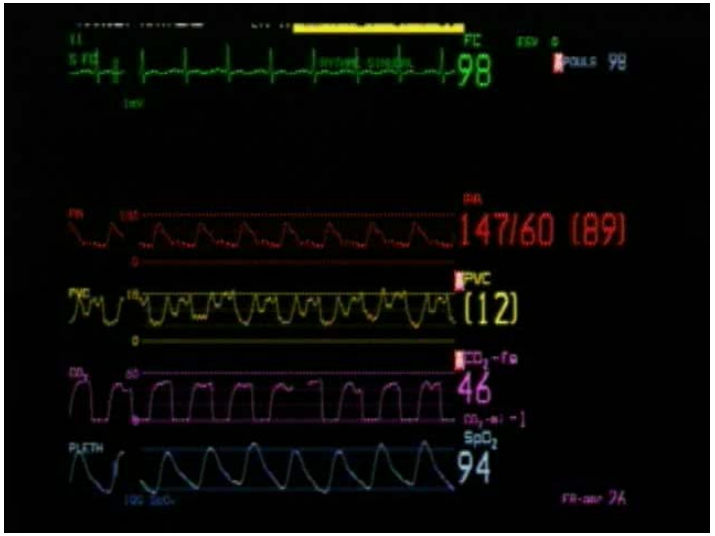
AJRCCM 1994;150:1722-1737

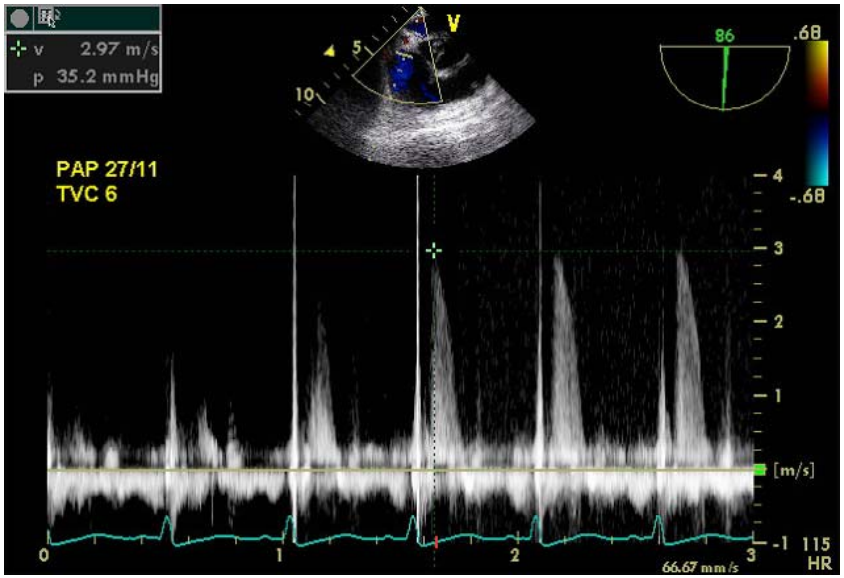
Homme de 68 ans ARDS
Effet hémodynamique de l'hypercapnie

Avant le retrait de ventilation 2re

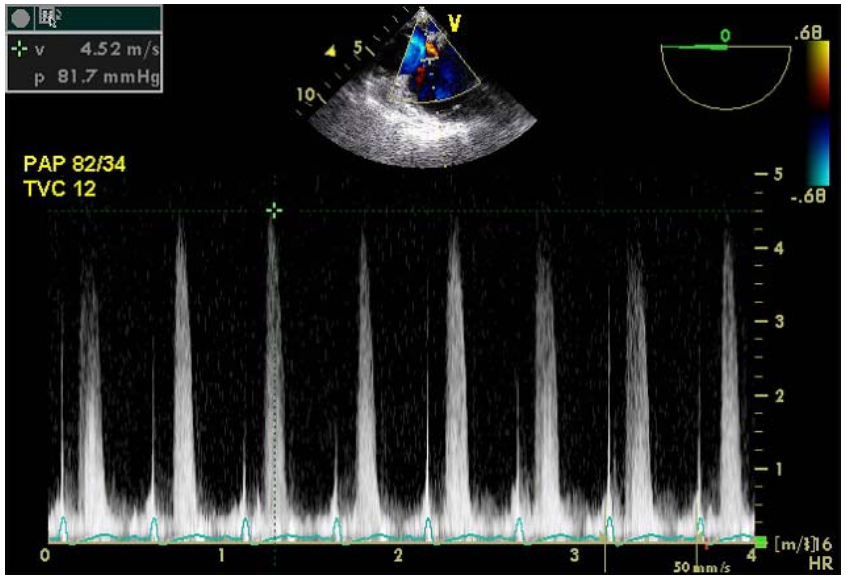


Après le retrait de ventilation 2re

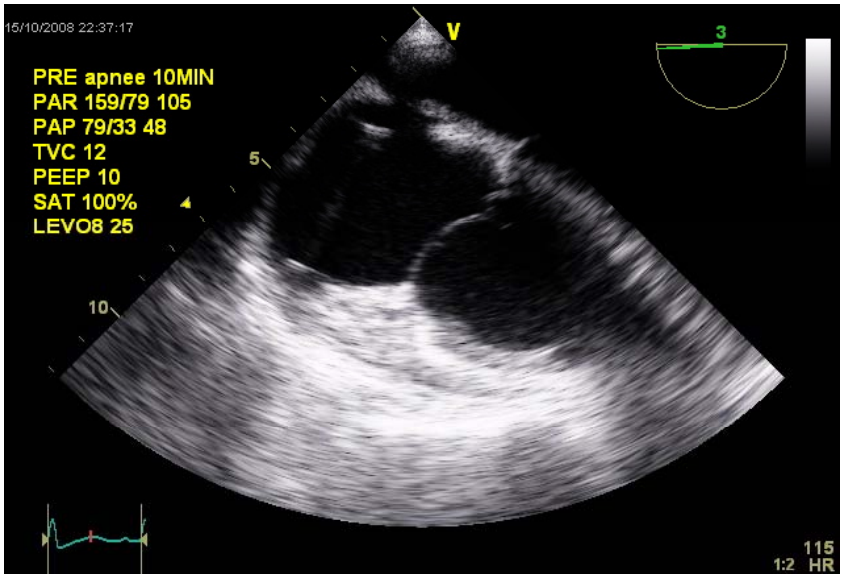
Début de l'apnée



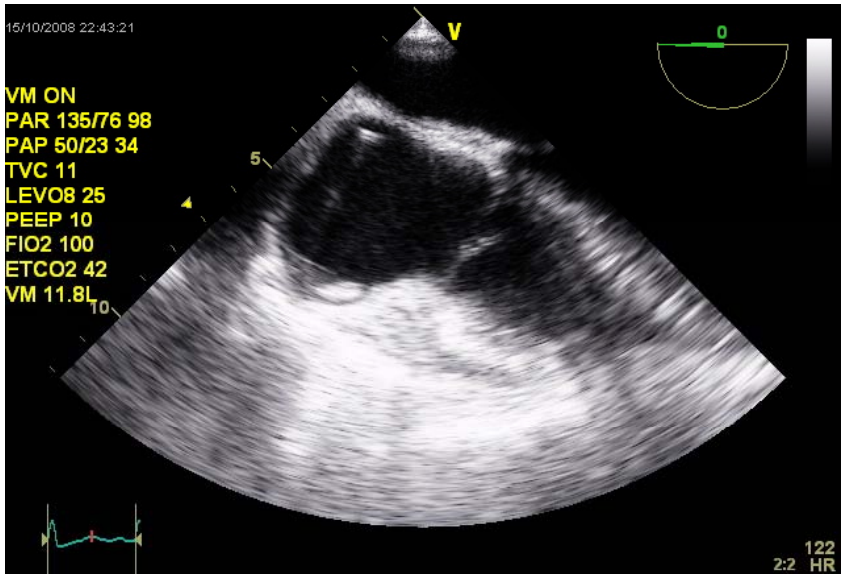
10 minutes d'apnée

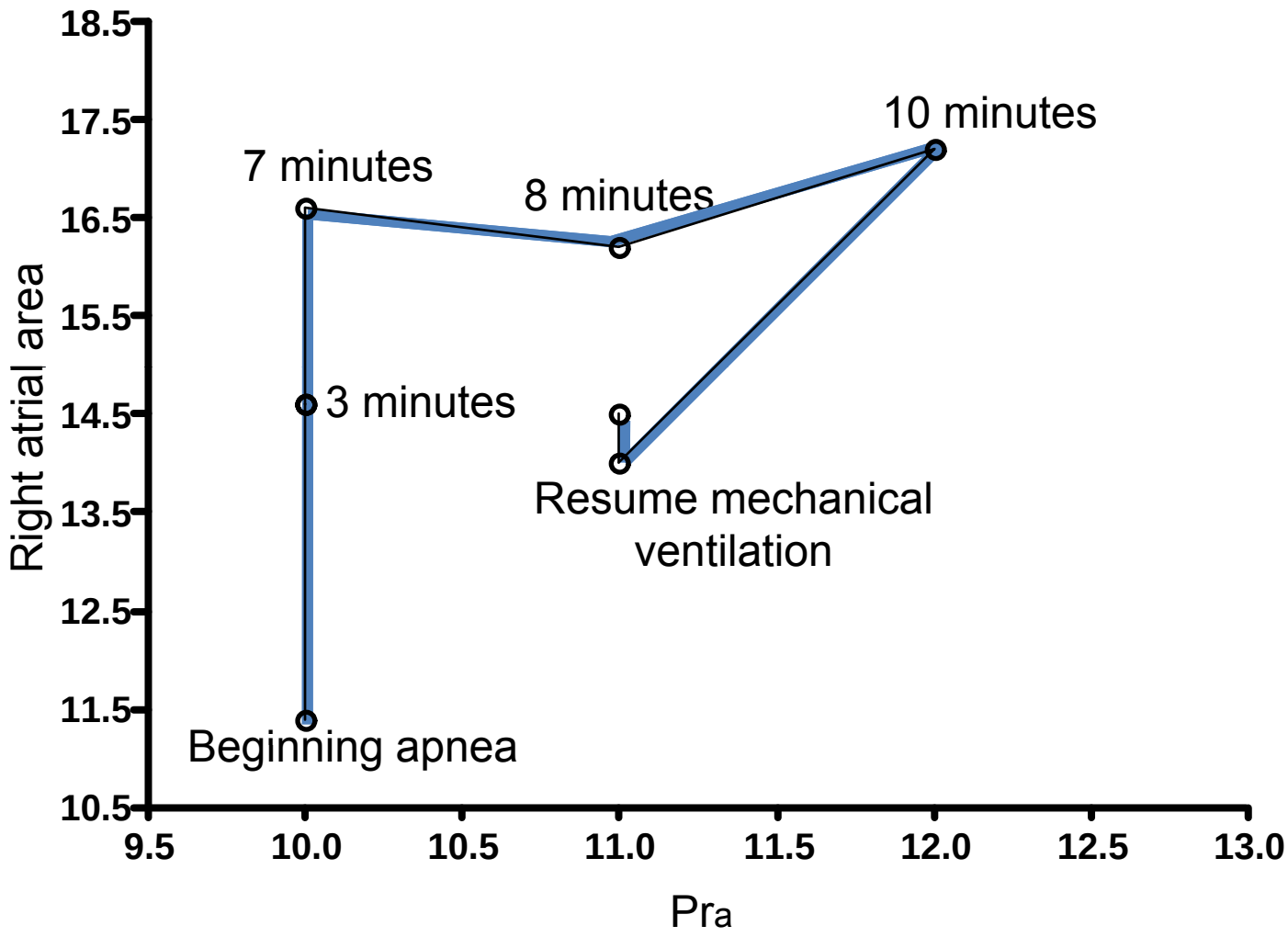


10 minutes d'apnée



Ventilation reprise




18.5
17.5
16.5
15.5
14.5
13.5
12.5
11.5
10.5
Right atrial area
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
Pra
10 minutes
7 minutes
8 minutes
3 minutes
Resume mechanical
ventilation
Beginning apnea

Effet de la ventilation a haute fréquence: avant

Ventilation haute fréquence

Effet neurologique

State of the Art

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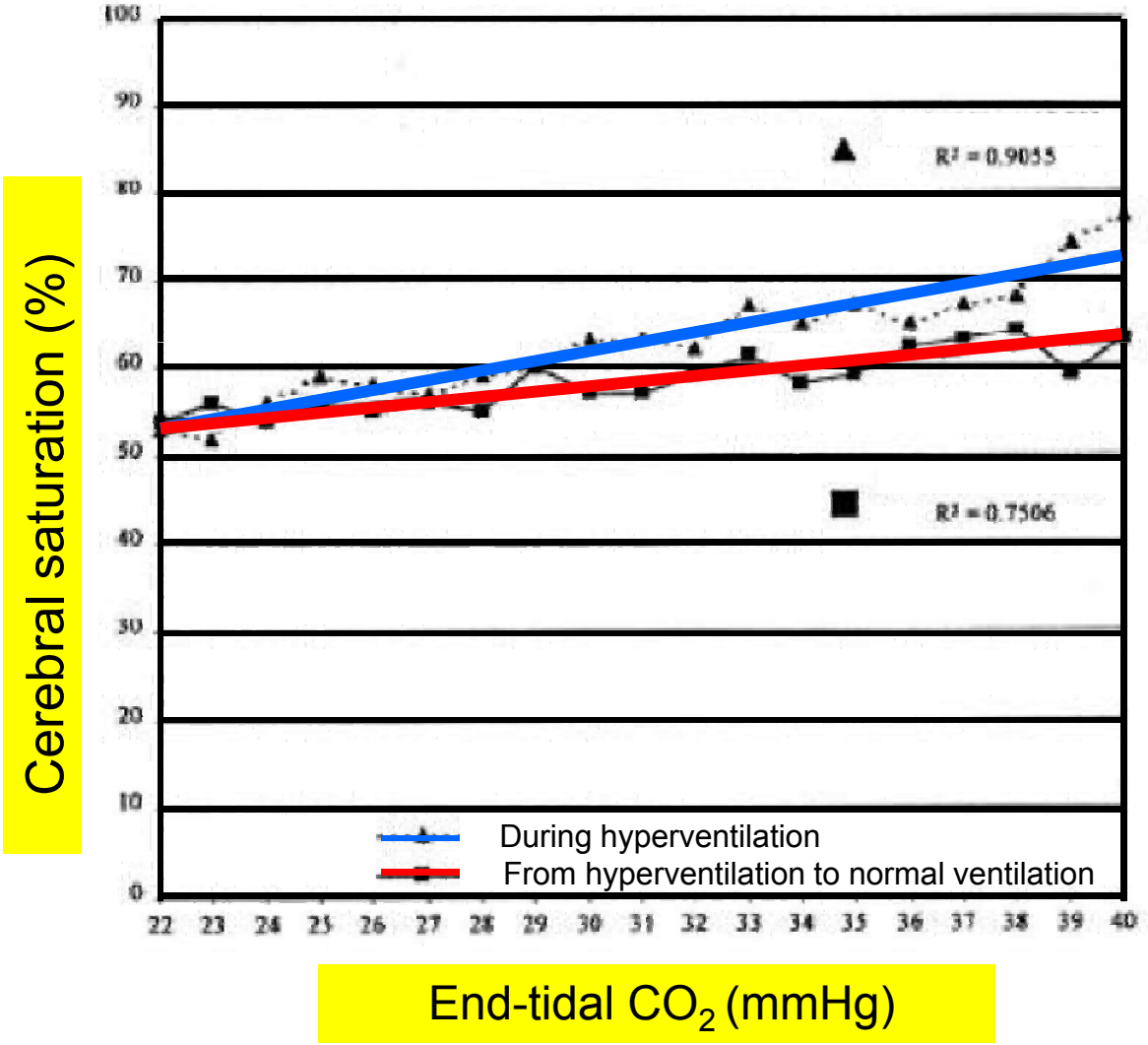
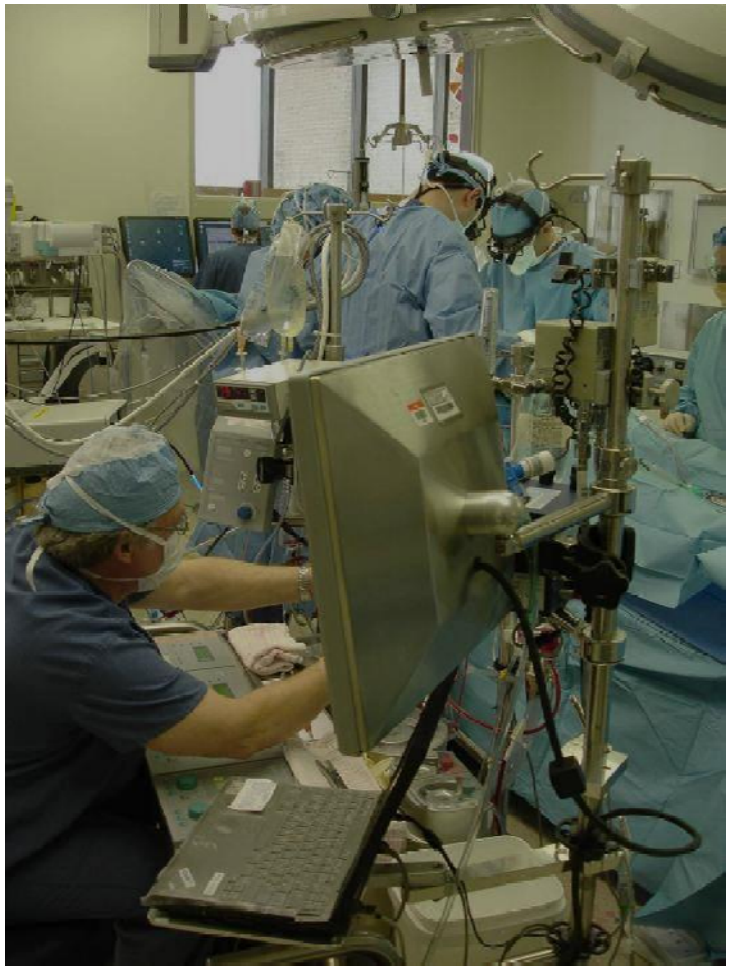
AJRCCM 1994;150:1722-1737

Ventilation et saturation cérébrale



Yao et al Anesthesiology 2000



Circulation-extracorporelle

♀ de 82 ans RVA

	Per désaturation	Après ↓ ventilation
pH	7.45	7.35 ↓
PCO_2	32	42 ↑
PO_2	375	294 ↓

Validation of NIRS Protocol

279 patients
Mean of 63 (28-87) years of age
Complex surgeries only
Prospective - observational
Anesthesiologists follow algorithm
Events are recorded
Success of intervention recorded

A. Deschamps, PhD, MD

FEBRUARY 2009

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

Université de Montréal

Cerebral Desaturations

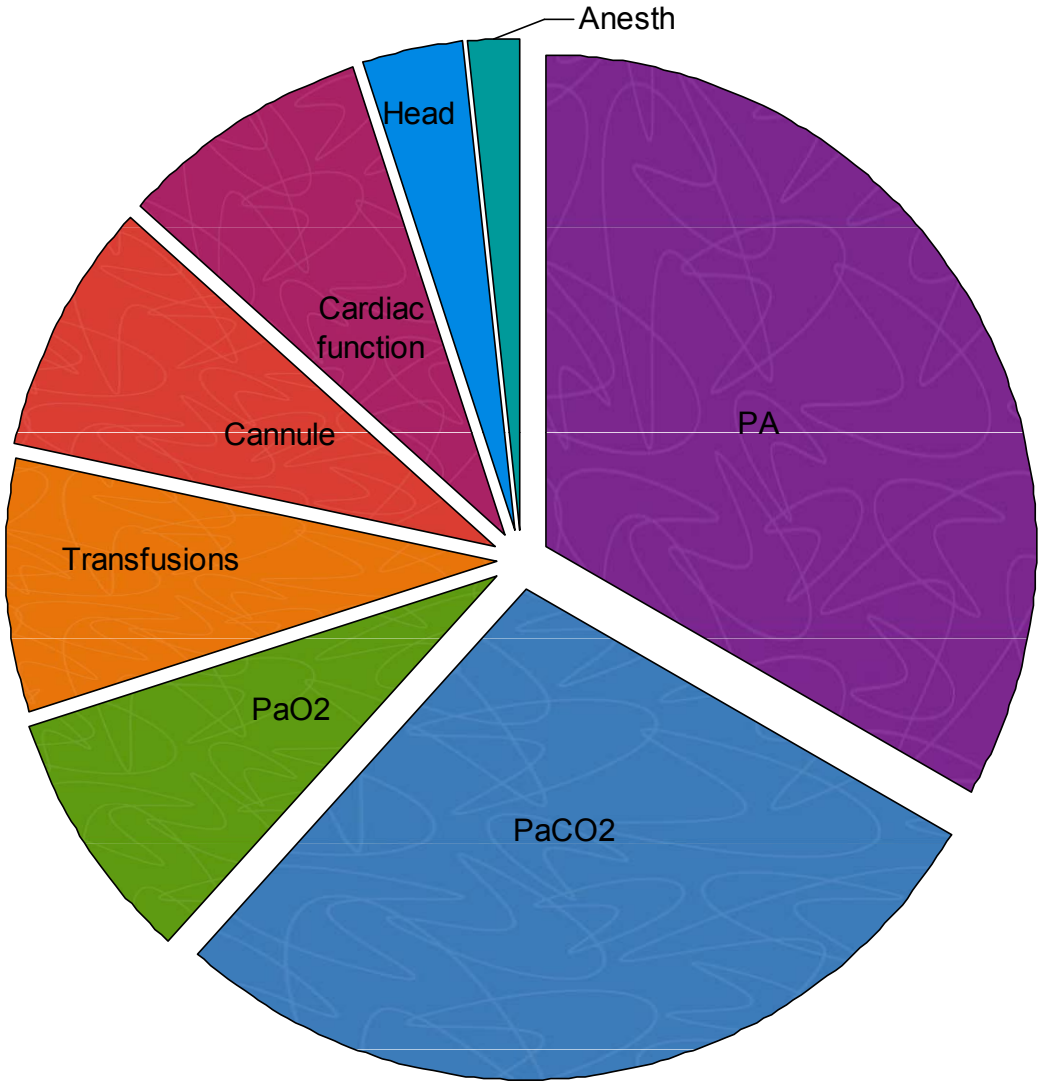
	% Patients
Pre CPB	27.3%
During CPB	56.1%
Post CPB	16.7%

A. Deschamps, PhD, MD

FEBRUARY 2009

Université de Montréal

Types of interventions



↑ PA	- 33.3%
↑ $PaCO_2$	- 28.33%
↑ PaO_2	- 8.33%
Transfusion	- 8.33%
Reposition Cannula	- 8.33%
↑ Cardiac Function	- 8.33%
Change head position	- 3.33%
↑ Anesthesia	- 1.67%

A. Deschamps, PhD, MD

FEBRUARY 2009

Université de Montréal

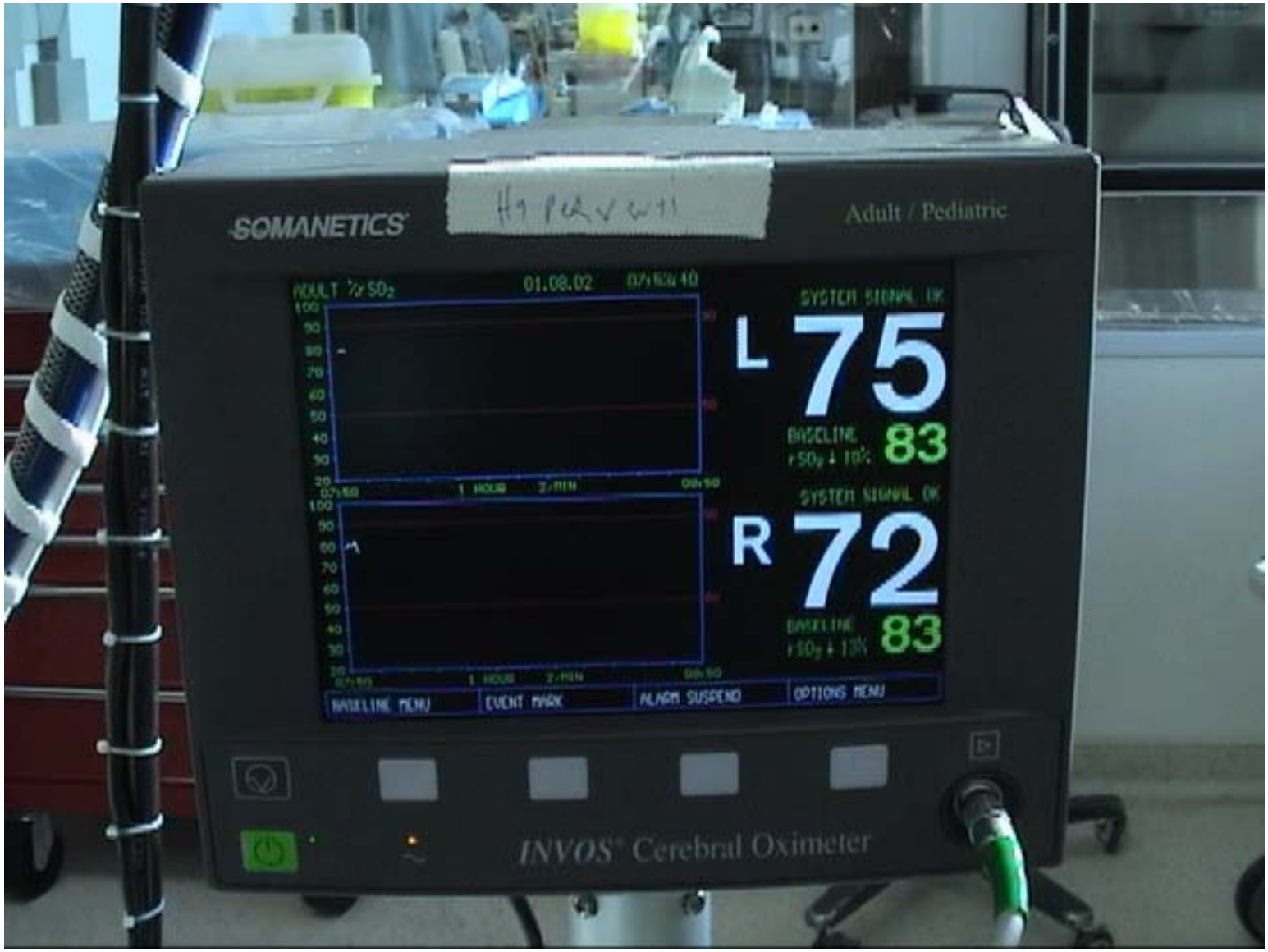
Effet neurologique de CO_2

55:55:35 - Lovell: « Houston, we've had a problem. We've had a main B bus undervolt. …a warning light showed that the carbon dioxide had built up to a dangerous level. »

Apollo XIII Ron Howard 1995

♂ de 24 ans: fermeture CIA

Hyperventilation éveillée



Intubation difficile

Homme de 47 ans obèse morbide

pH = 7.37

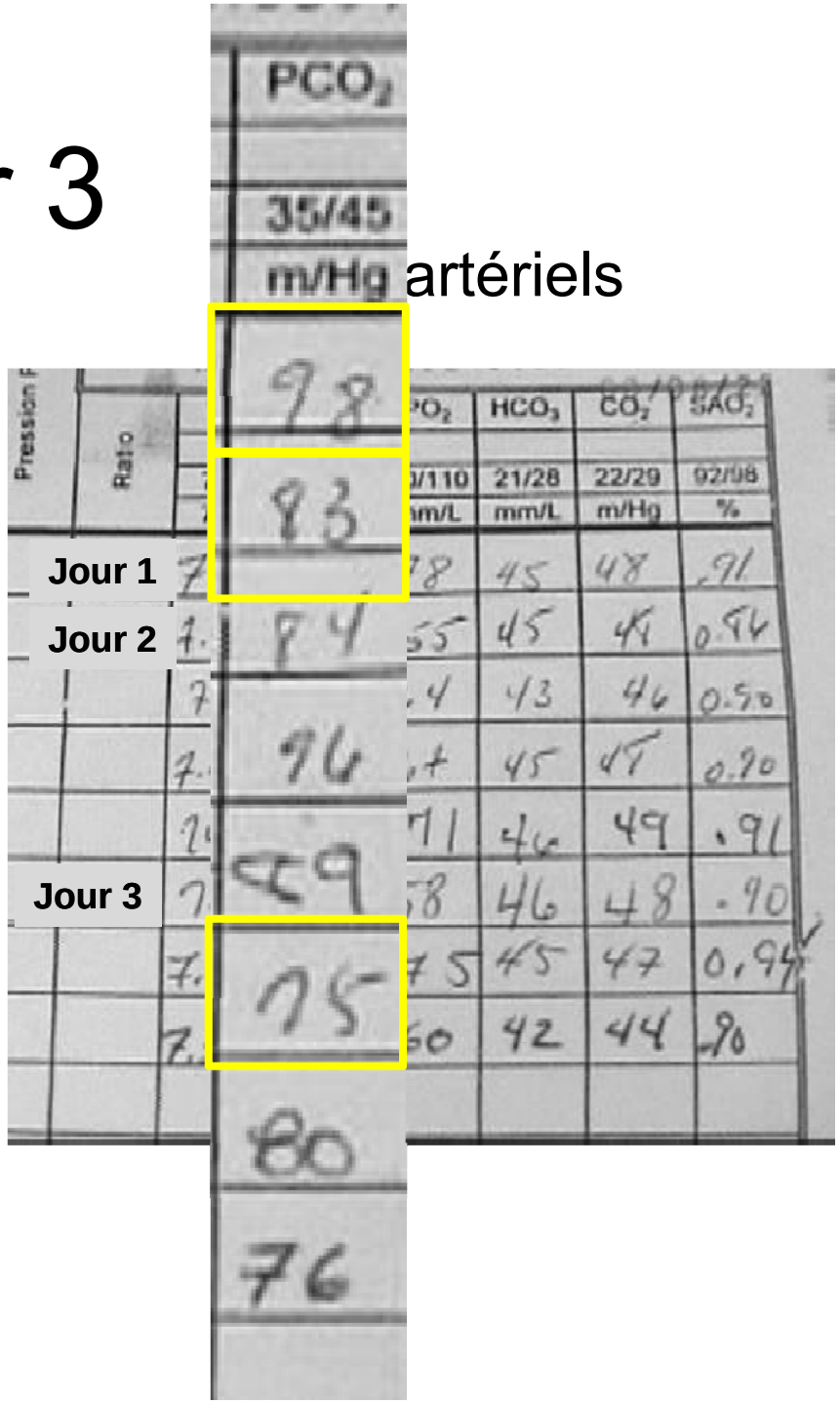
PCO_2 = 98 mmHg

Jour 2

pH = 7.34

PCO_2 = 83 mmHg

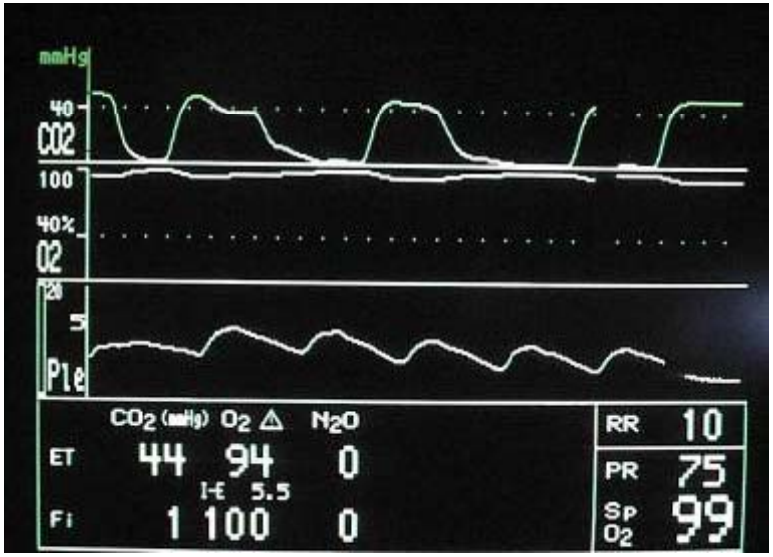
Jour 3


PCO2
35/45
m/Hg
artériels
98
83
84
96
79
75
80
76
Jour 1
Jour 2
Jour 3
Pression
Ratio
HCO3
CO2
SAO2
21/28
22/29
92/98
mm/L
m/Hg
%

Homme de 59 ans MPOC décompensé

Homme de 49 ans: EPS flutter

Agitation en fin de procédure



Plan

1-Méthodes et système de mesure

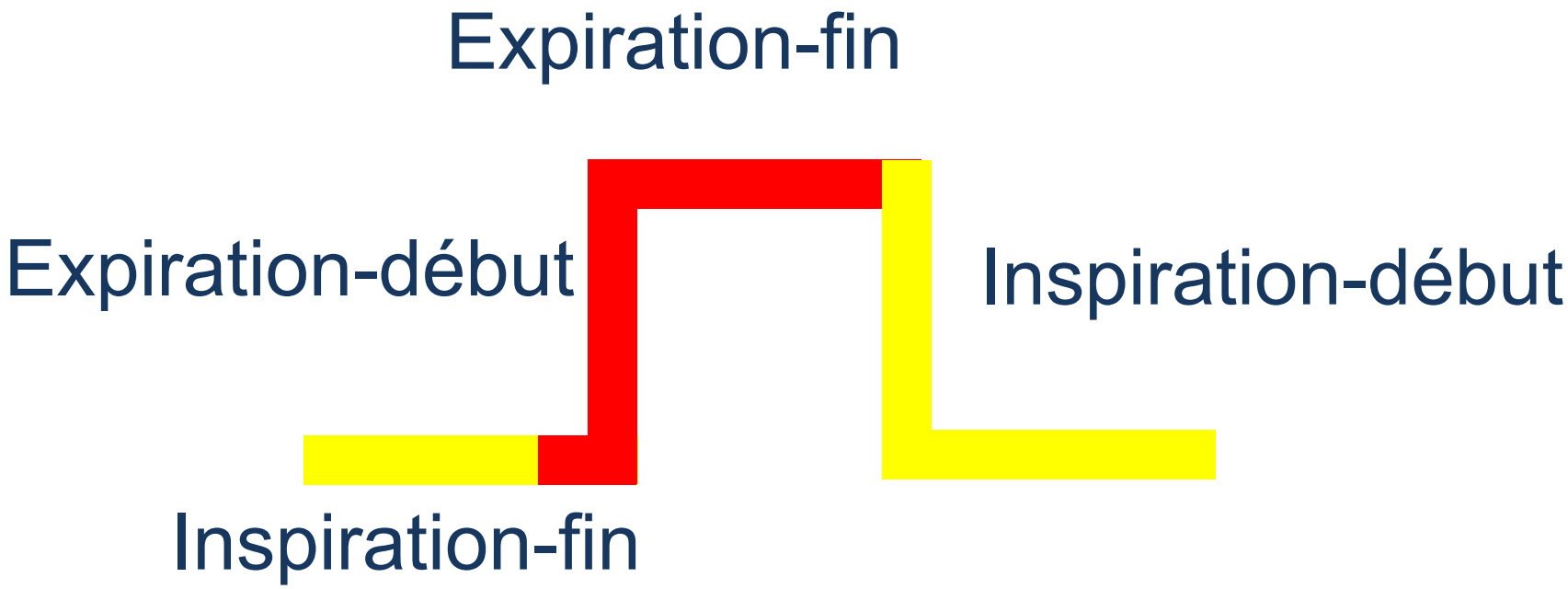
2-Physiologie du CO_2

3-Courbes de CO_2

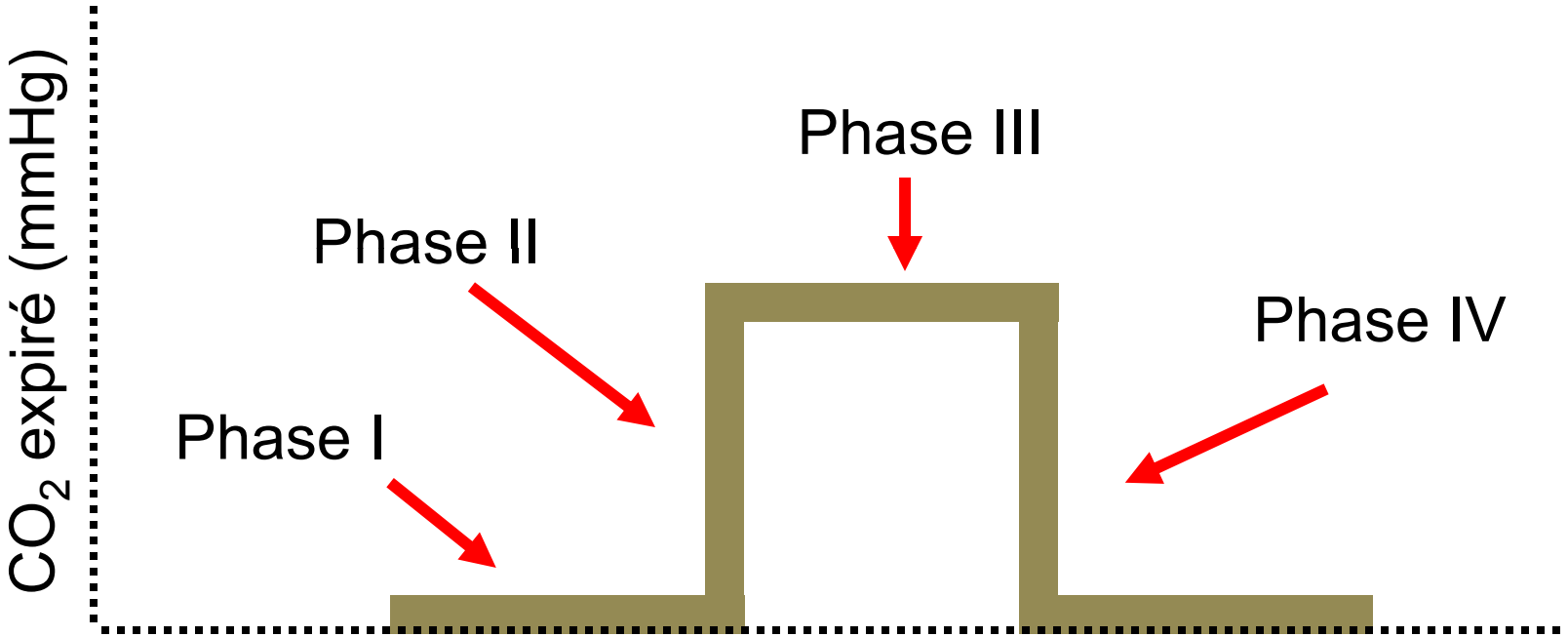
4-CO_2 volumétrique

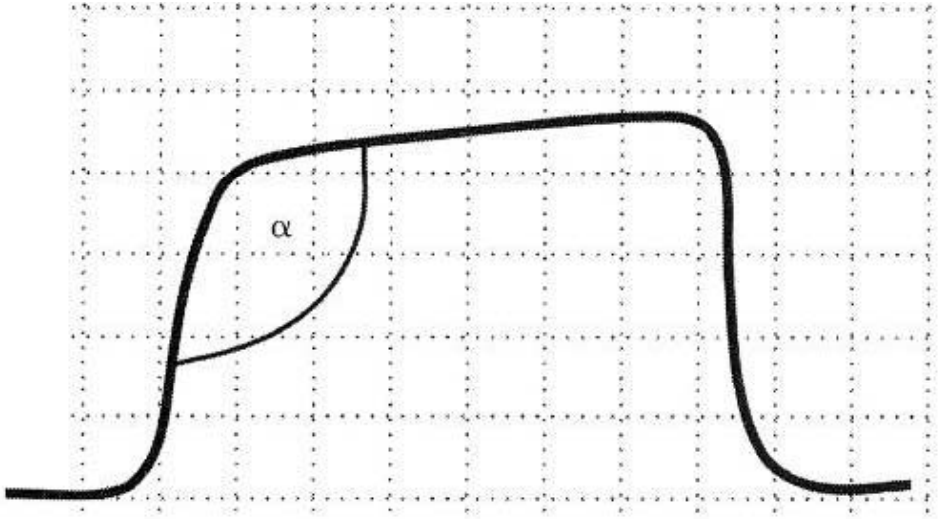
5-Autres applications

Tracé capnographique

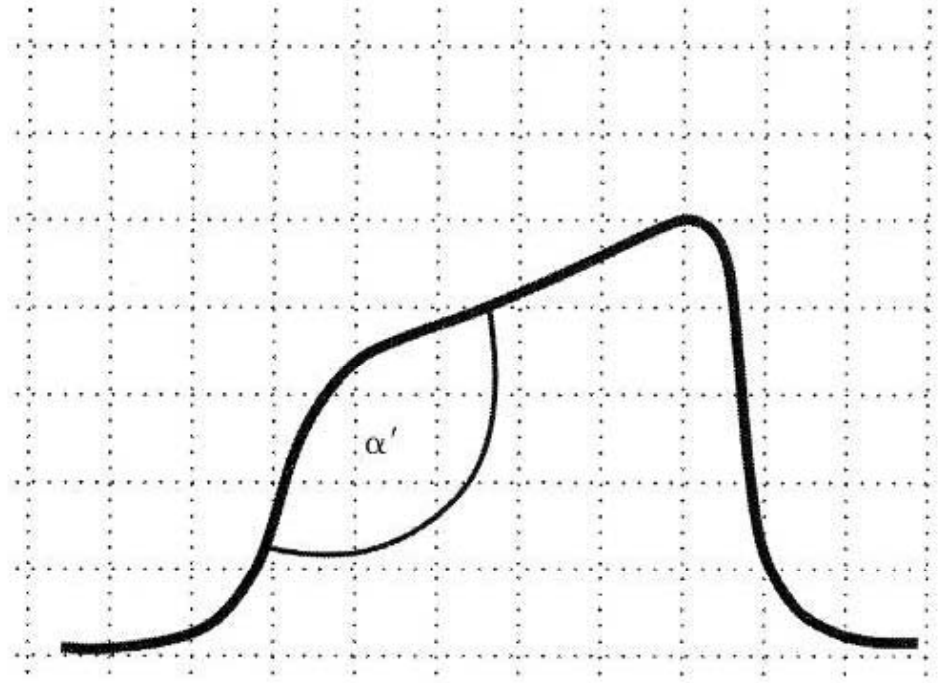


Tracé capnographique





(a)



(b)

Angle α

Normale 105º

Phase III: selon anomalies V/Q et la constante de temps

Analyse des courbes de capnographie

1-CO_2 présent?

2-Forme de la phase I, II, III et IV

3-Valeur à la fin de l'expiration

4-Différence entre la $PaCO_2$ et CO_2 expiré

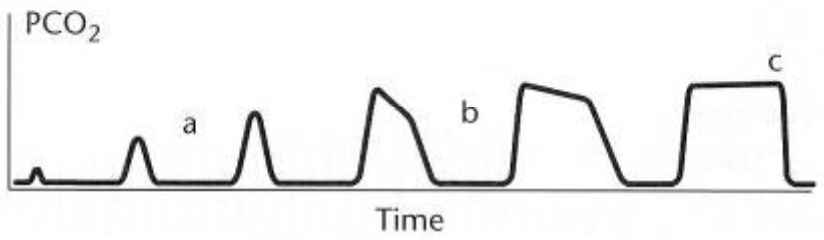
5-Différence entre la $PvCO_2$ et le CO_2 expiré

Intubation et capnographie

Time is brain!

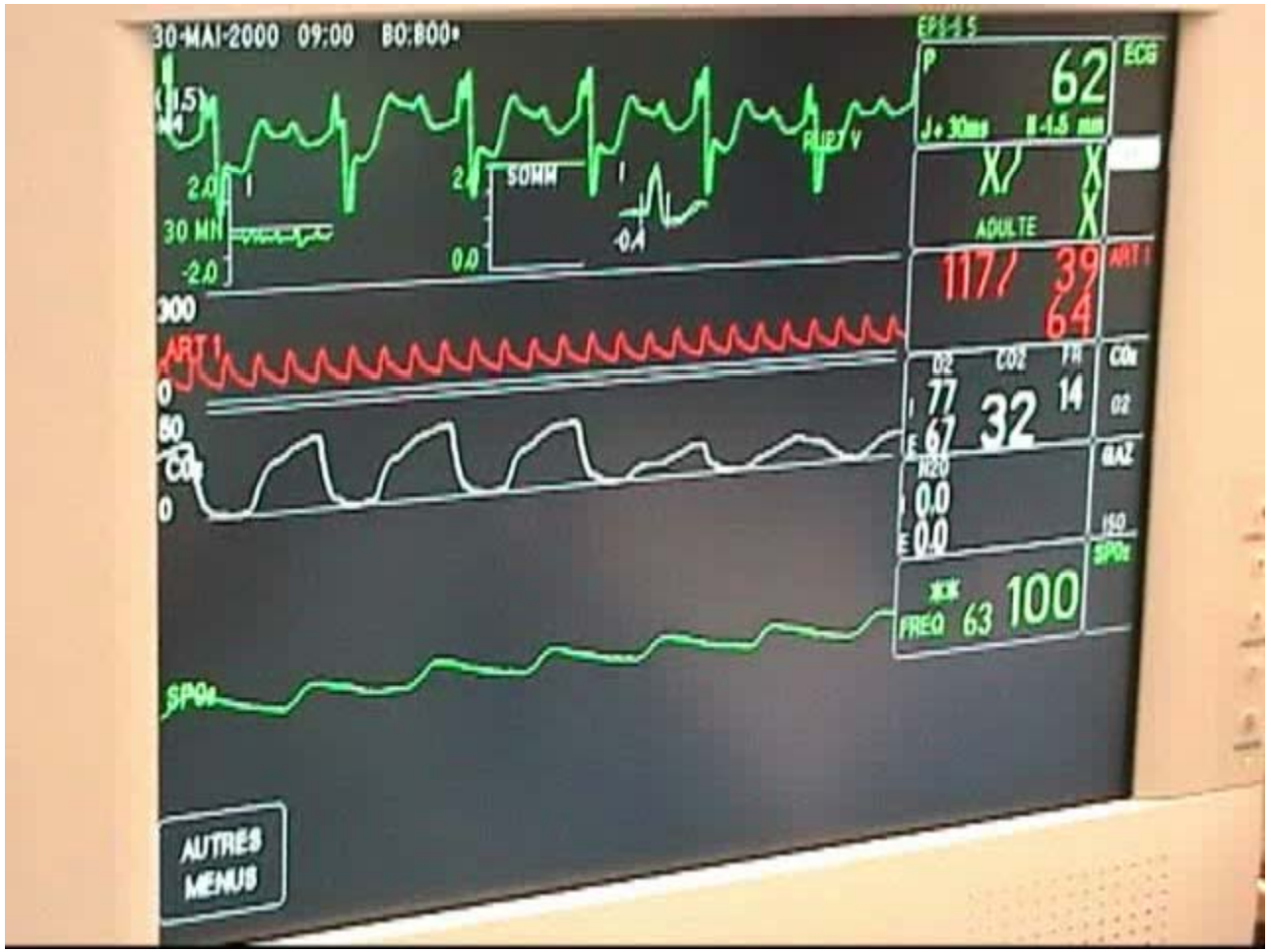
Intubation et capnographie

- TET malpositionné en pré-hospitalier:
  - 7-25% (66% esophage et 33% hypopharynx) (Silvestri 2003;Acad Emer med 10:445)
  - Intubation à l'aveugle

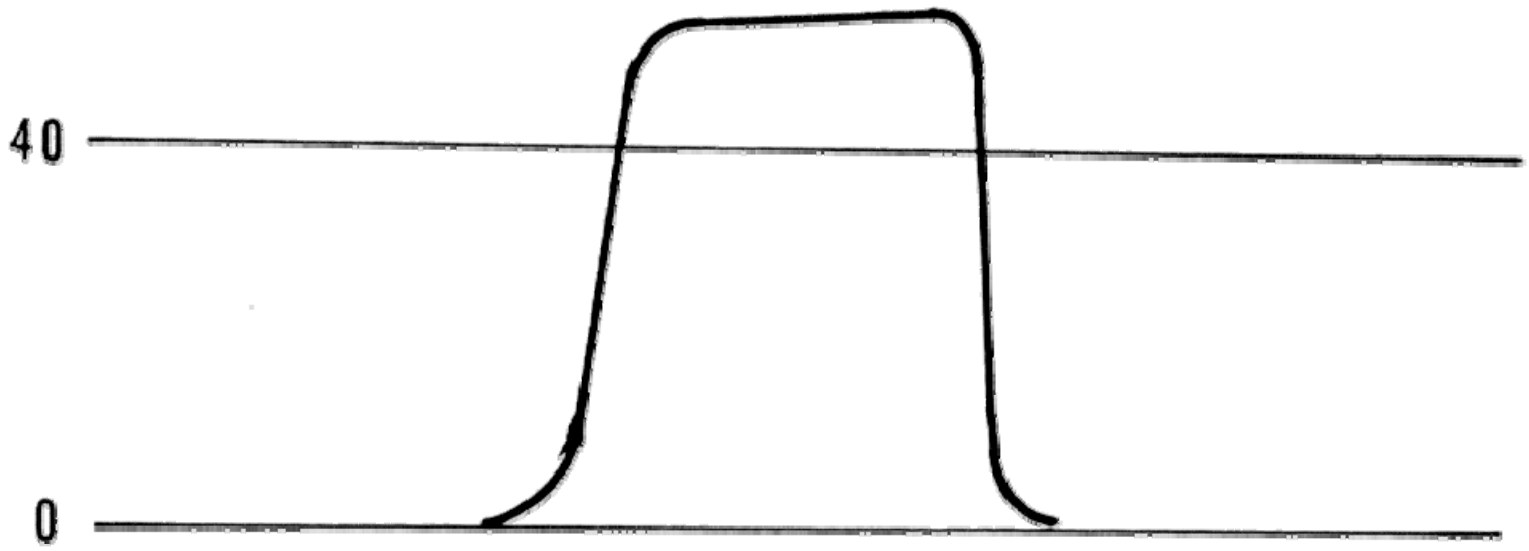


- Intubation esophage:
  - Mouvement epigastrique normal 90%
  - Condensation TET 85%

Que se passe-t-il?



Exemple: à la fin d'une HAT



Exemple: à la fin d'une prostatectomie

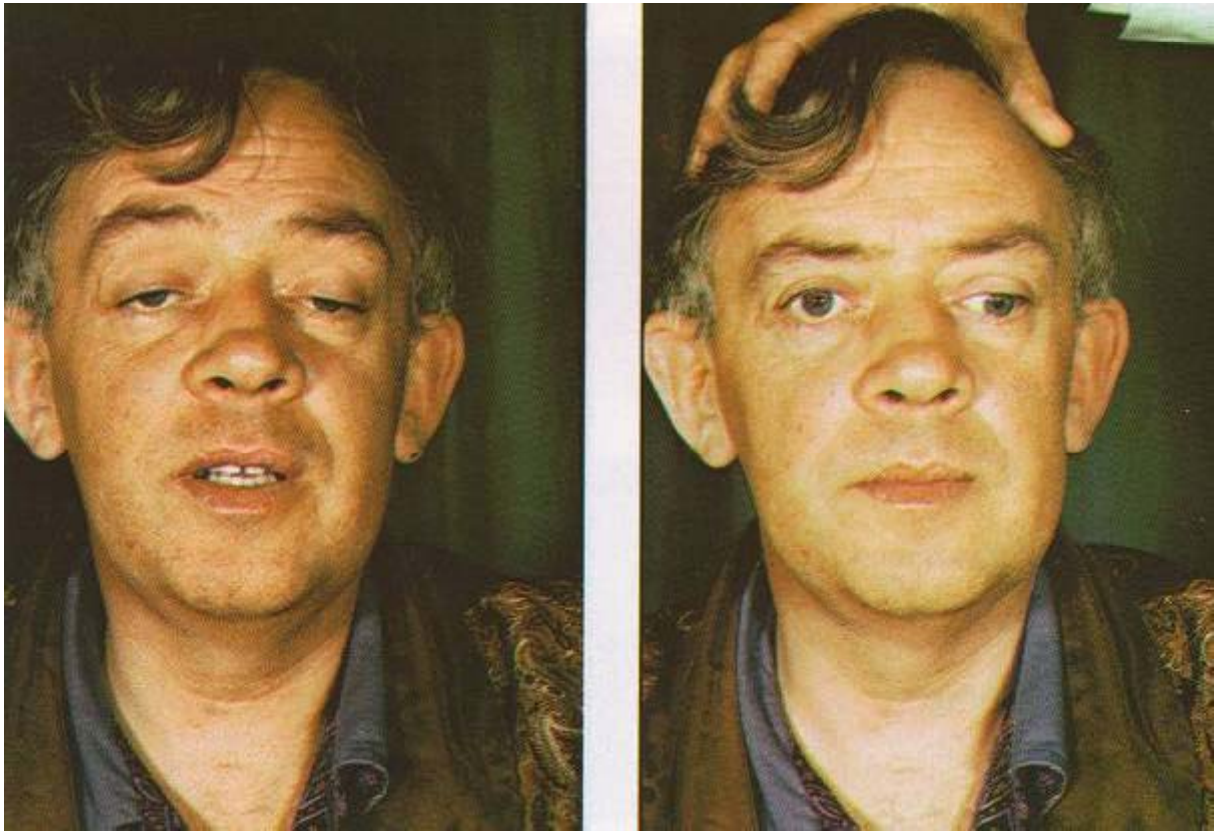
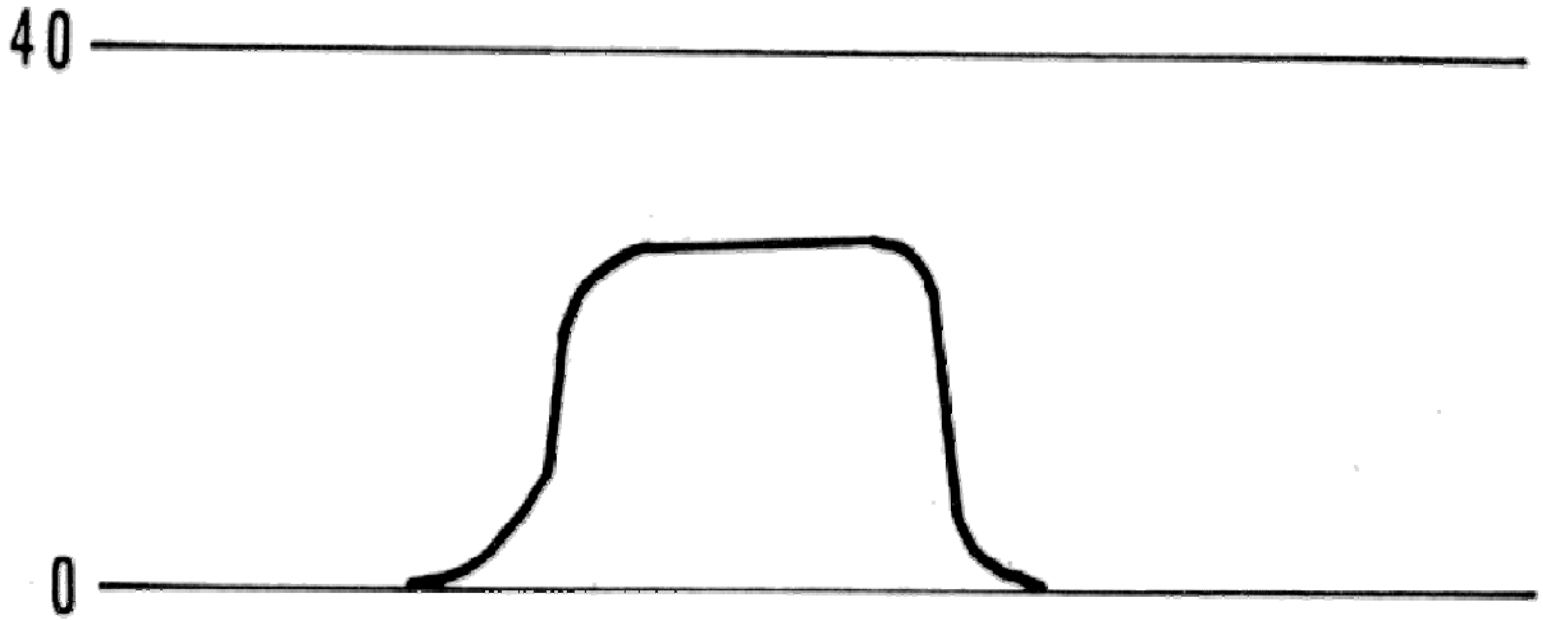


Photo Diagnosis 1996

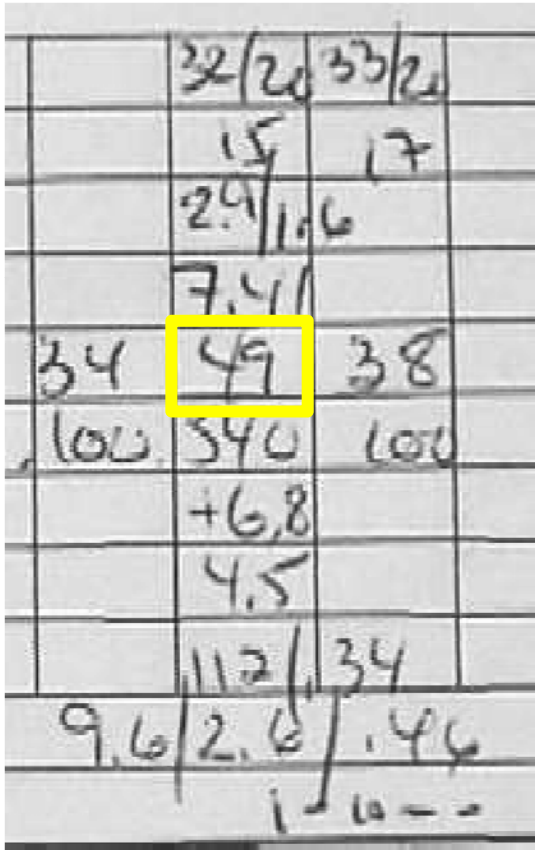
Exemple: patiente de 85 ans



Différence PaCO2-ETCO2: 1.5 mmHg / décade

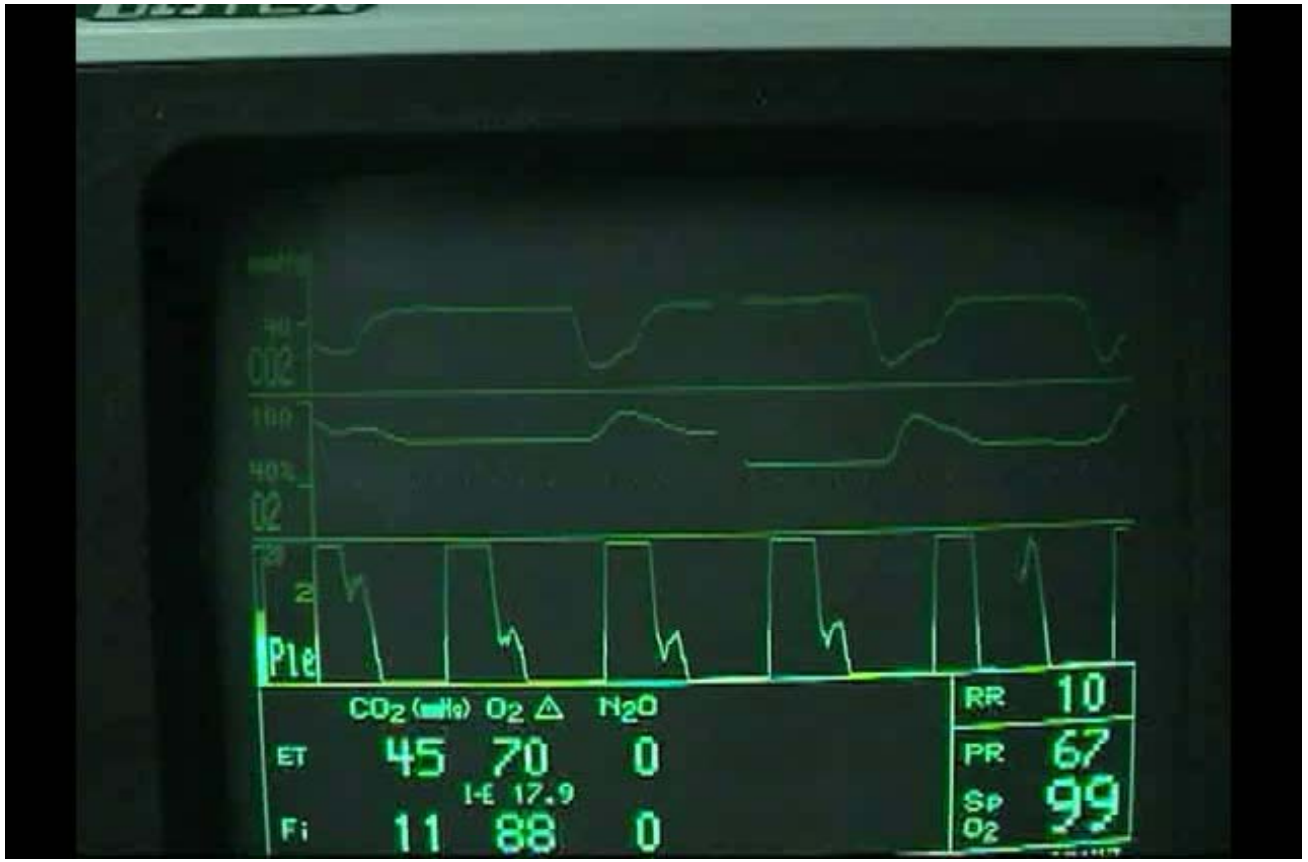
Quel est le problème et conséquence?

Résultat


32/20
33/20
15
17
29
1.6
7.41
34
49
38
100
340
100
+6.8
4.5
112
34
9.6
2.6
.46


Adult / Pediatric
SYSTEM SIGNAL OK
L
79
BASELINE
74
SYSTEM SIGNAL OK
R
74
BASELINE
70
OPTIONS MENU

Ou est le problème?




5L
4L
3L
2L
1L
L/min
C
300
200
100
20
mL/min
A
4L
3L
2L
1L
700
L/min
C


mmHg
Pleth
CO2 (mmHg) O2 △ N2O
ET 47 59 0
I:E 7.1
Fi 7 66 0
RR 10
PR 66
SpO2 99
08:46
AUDIO ALARM OFF

Quel est le diagnostique: preuve?

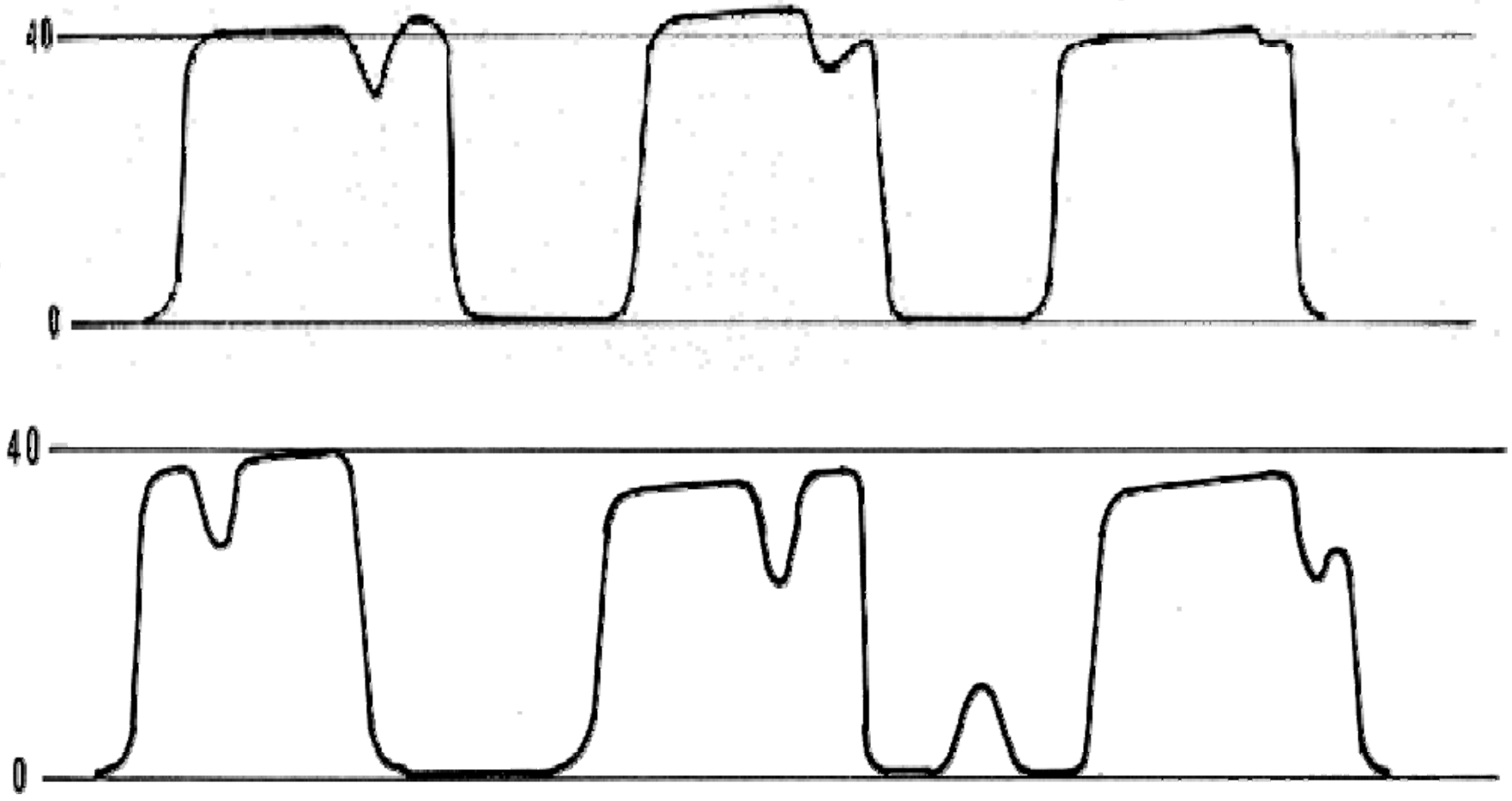
Oscillations cardiaques

Homme de 45 ans après greffe pulmonaire.

Autre exemple: sur courbe O_2

♂ 72 ans débridement de plaie sternale

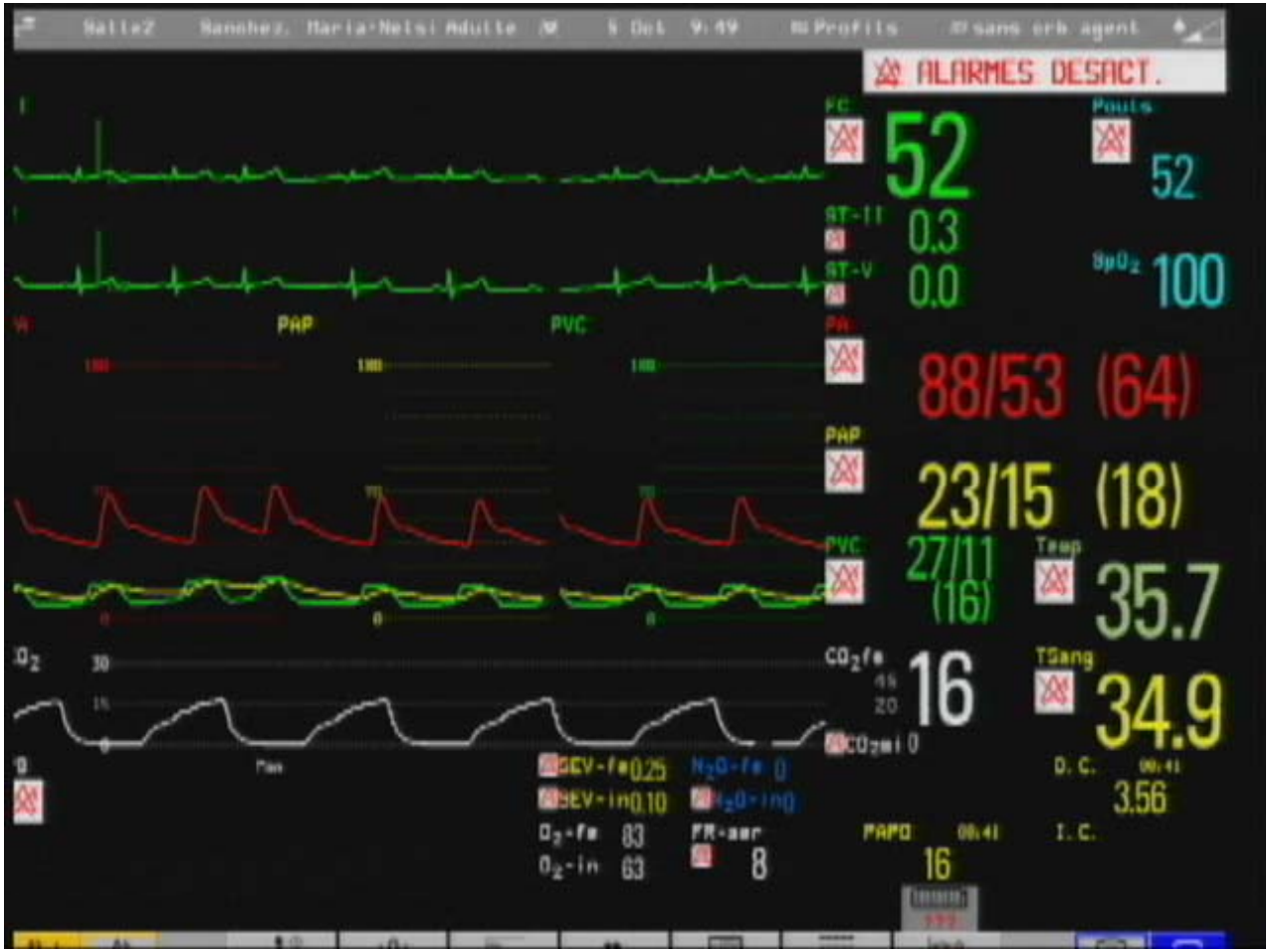
Exemple: que s'est-il passé et pourquoi le CO_2 expiré augmente?



"Curare cleft“ danger!!!

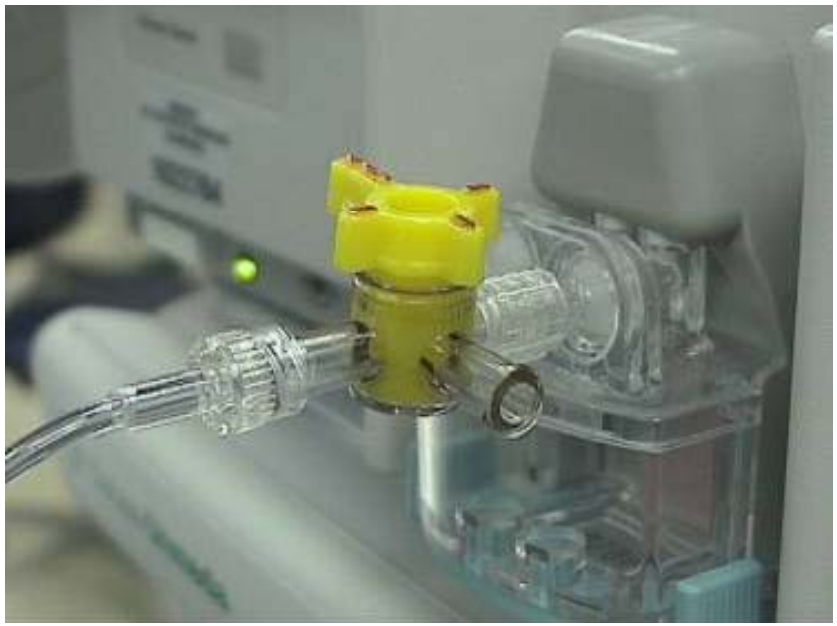
- Hypercapnie
- Douleur
- Pousser sur thorax
- Hocquet

Quel est le problème?

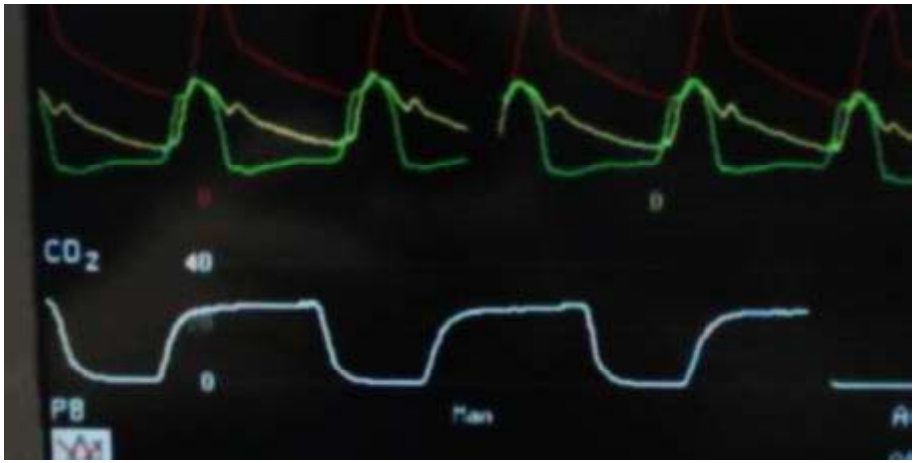


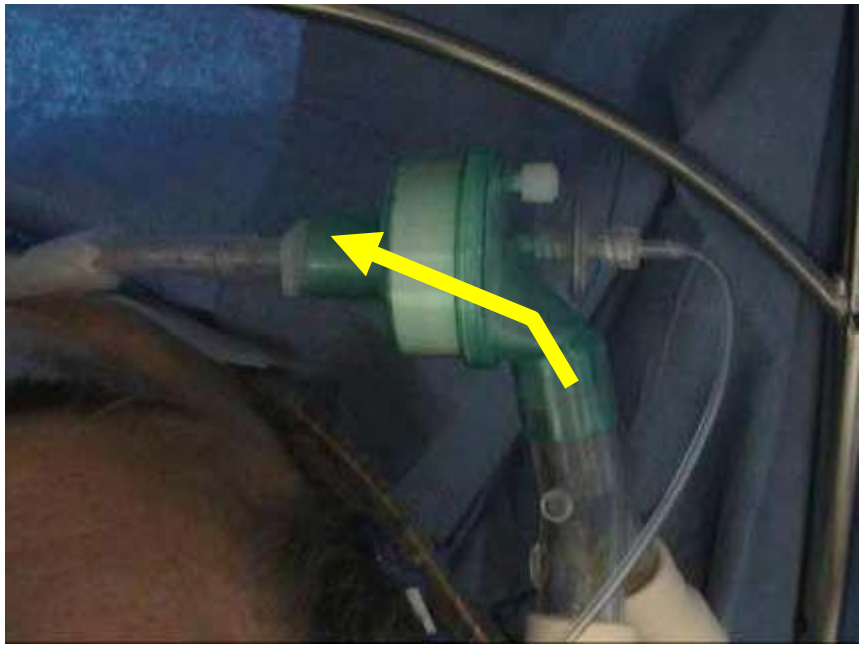

ALARMES DESACT.
52
52
0.3
0.0
100
88/53 (64)
23/15 (18)
27/11 (16)
35.7
16
34.9
3.56
8
16

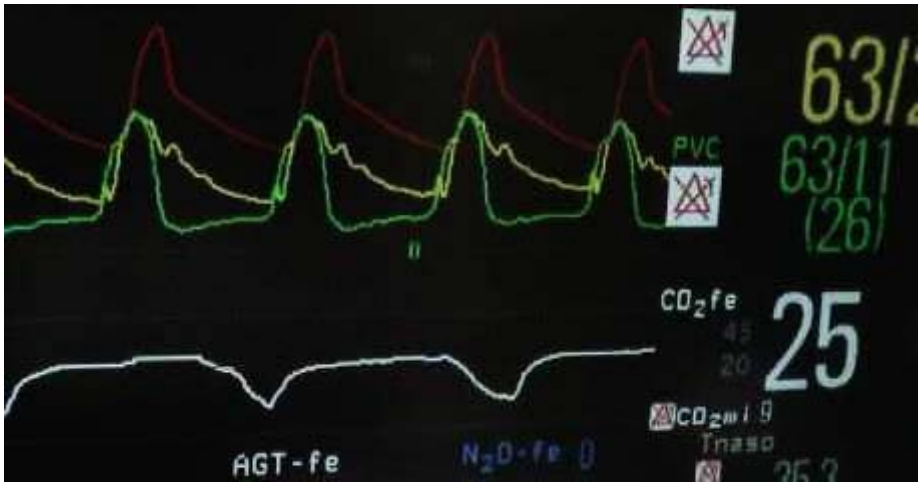

ALARMES DESACT.
61
61
0.3
100
125/75 (92)
36/22 (27)
33/15 (23)
36.3
22
8
16

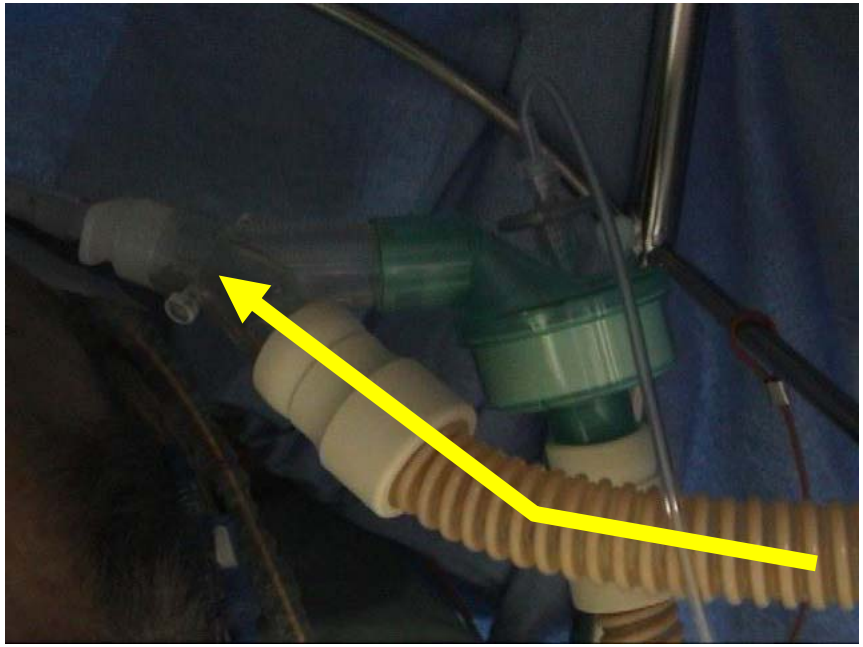


Réinspiration



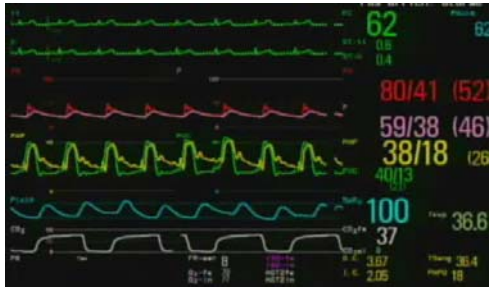






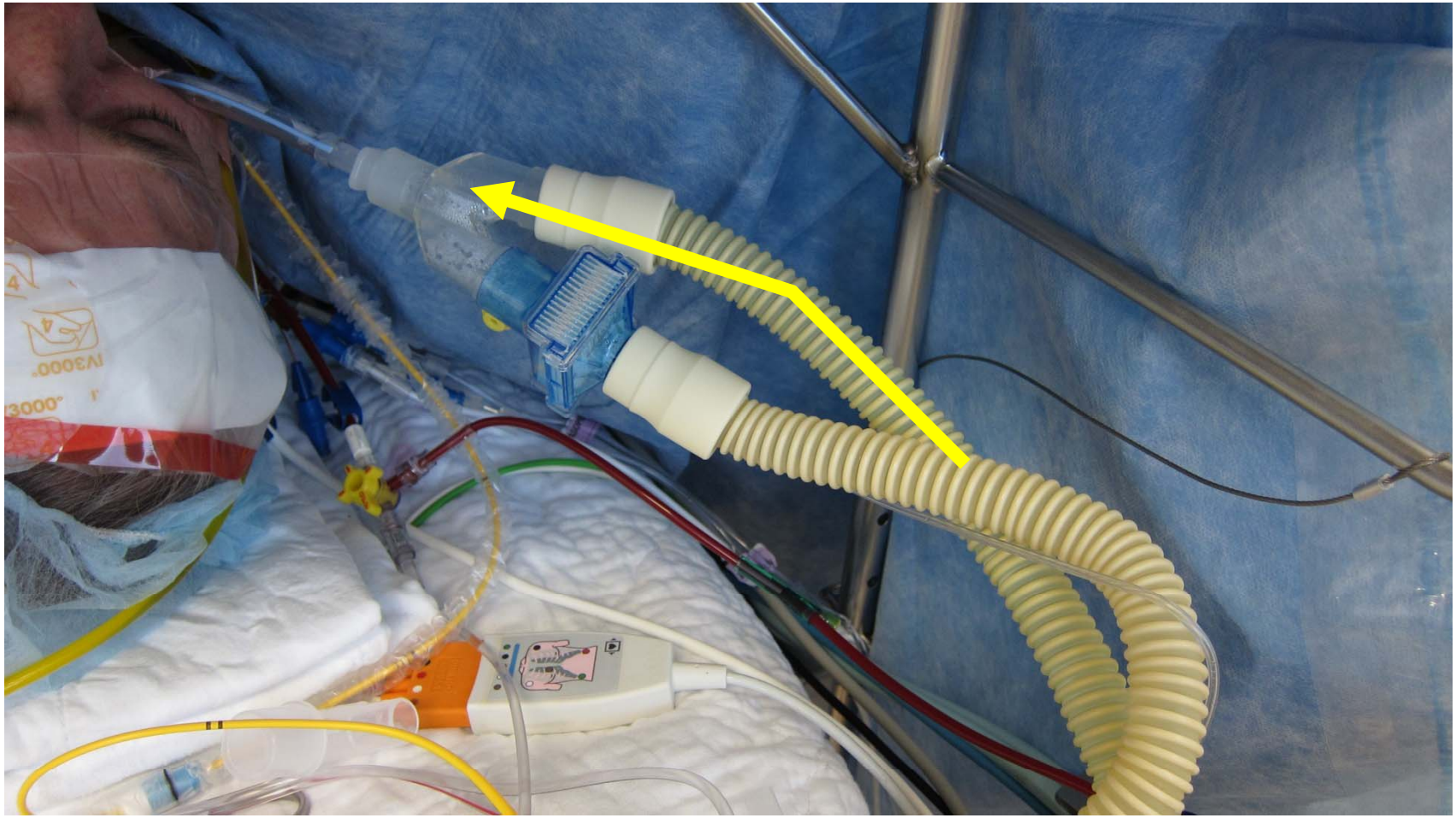
Échantillonage latéral

Mécanisme?

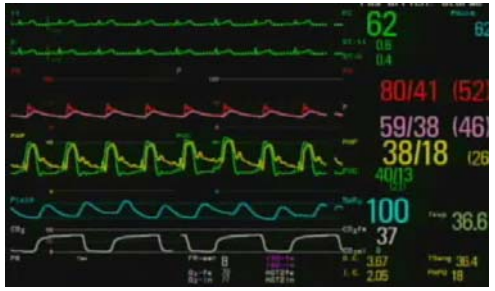

62
80/41
59/38
38/18
100
37


Pas affich. alarme
69
68
89/51 (66)
92/49 (64)
47/29 (35)
99
36.5
40
10
5.11
2.85
36.2
18

Dans branche expiratoire



Mécanisme?

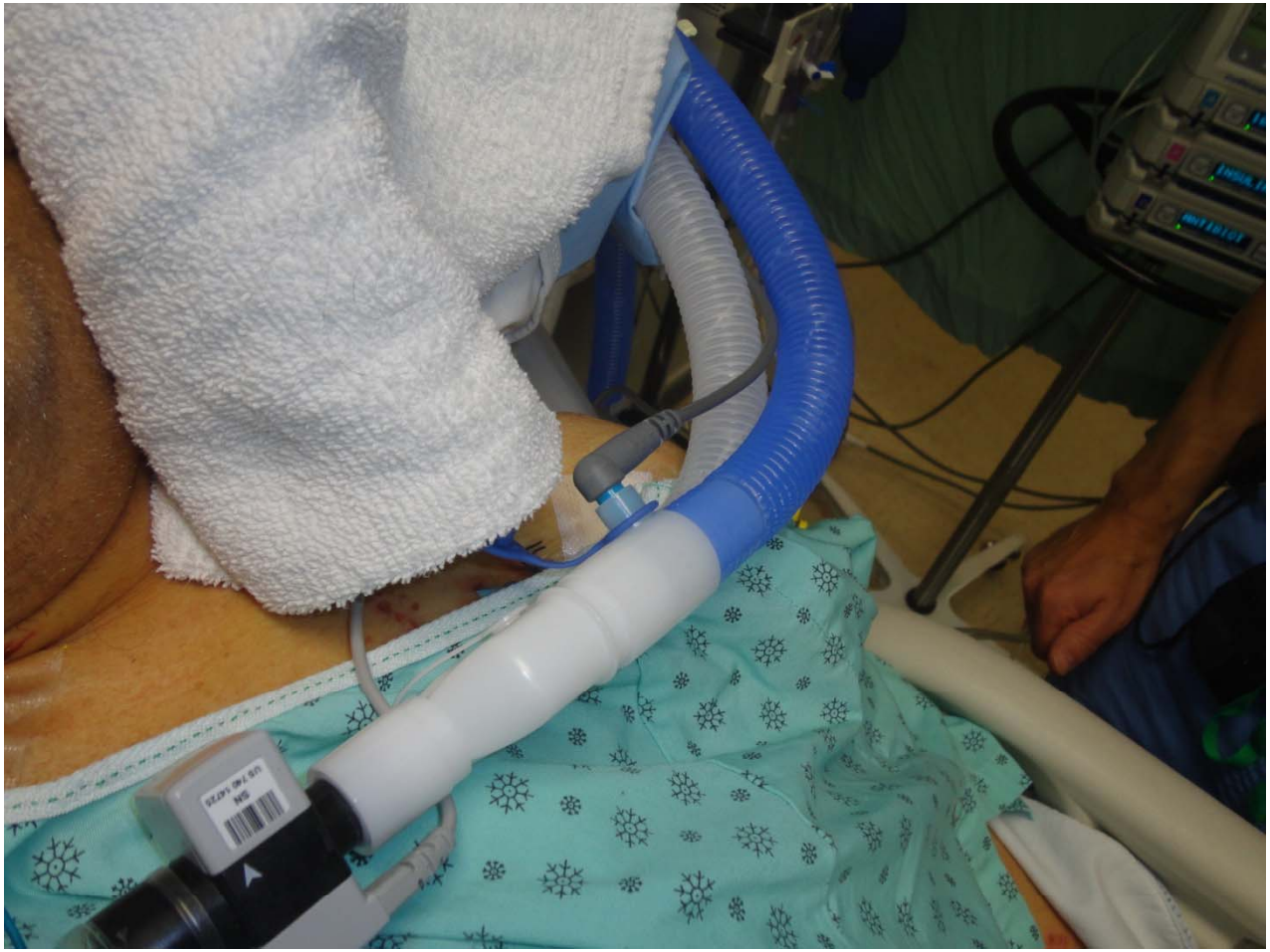

62
80/41
59/38
38/18
100
37
36.6


67
89/51
92/49
46/26
100
29
36.6
10
5.11
2.85
18

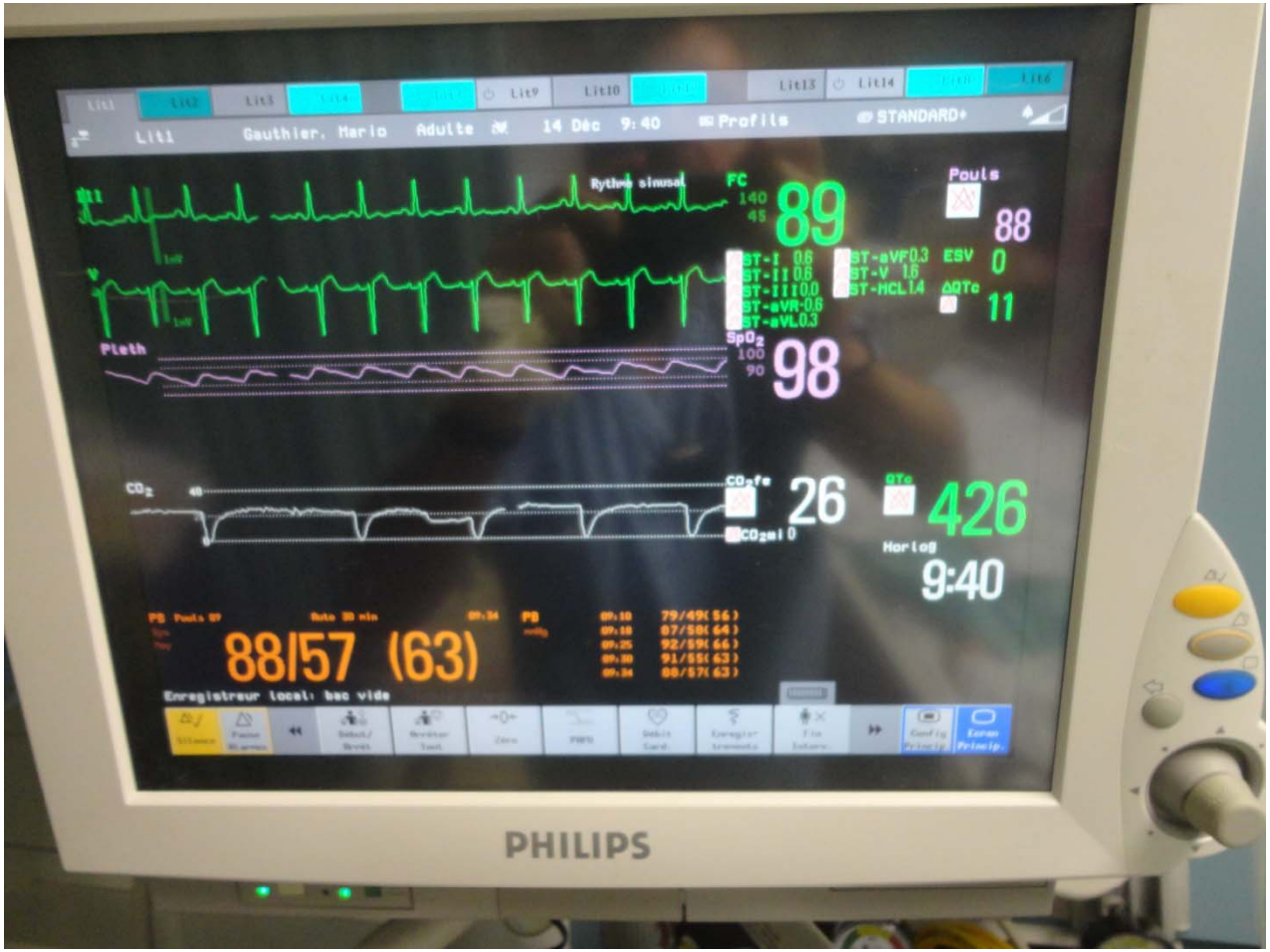
Dans branche inspiratoire

Échantillonage central

CHUM: Bleu = inspiratoire

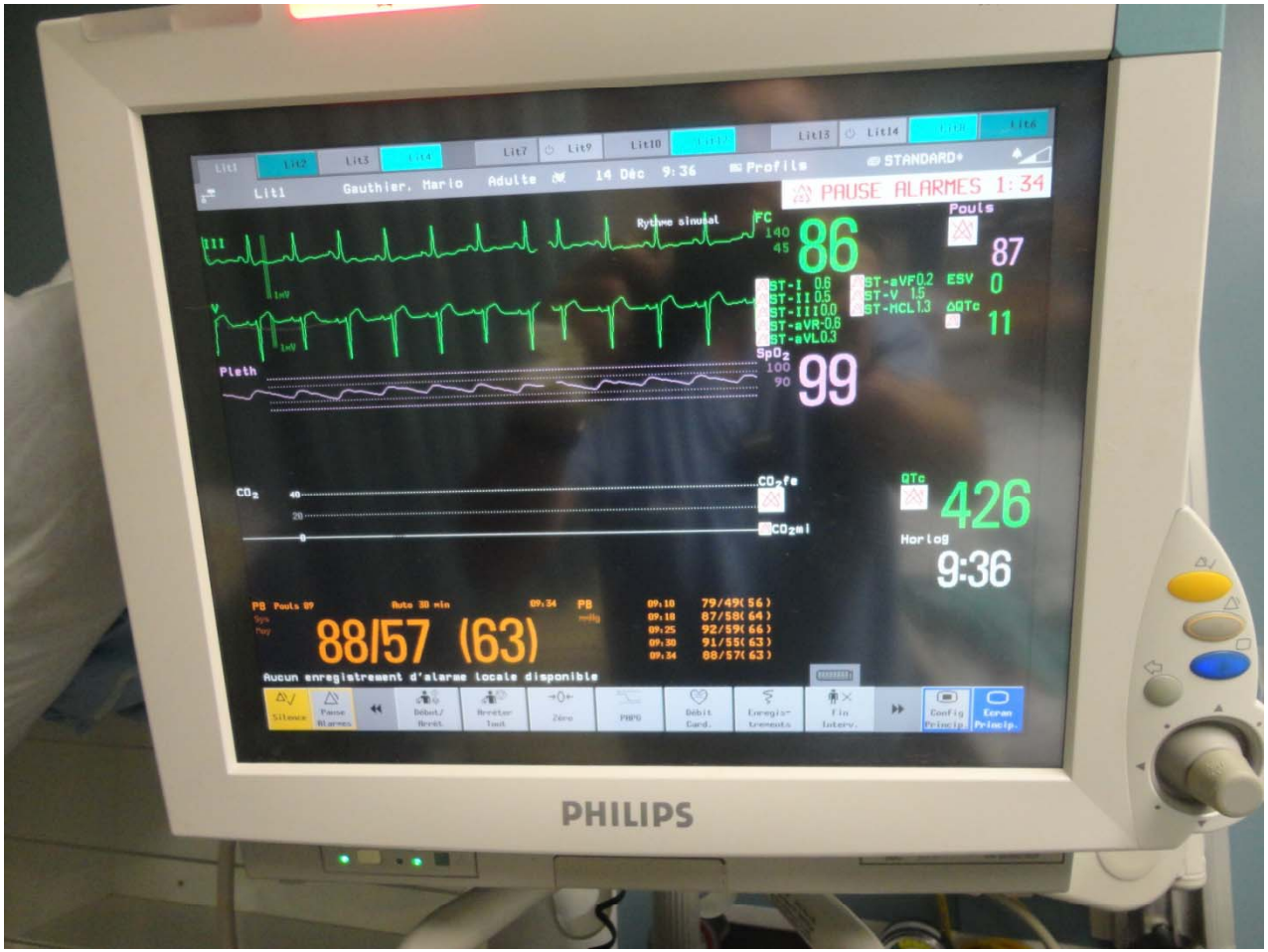


Que se passe-t-il?

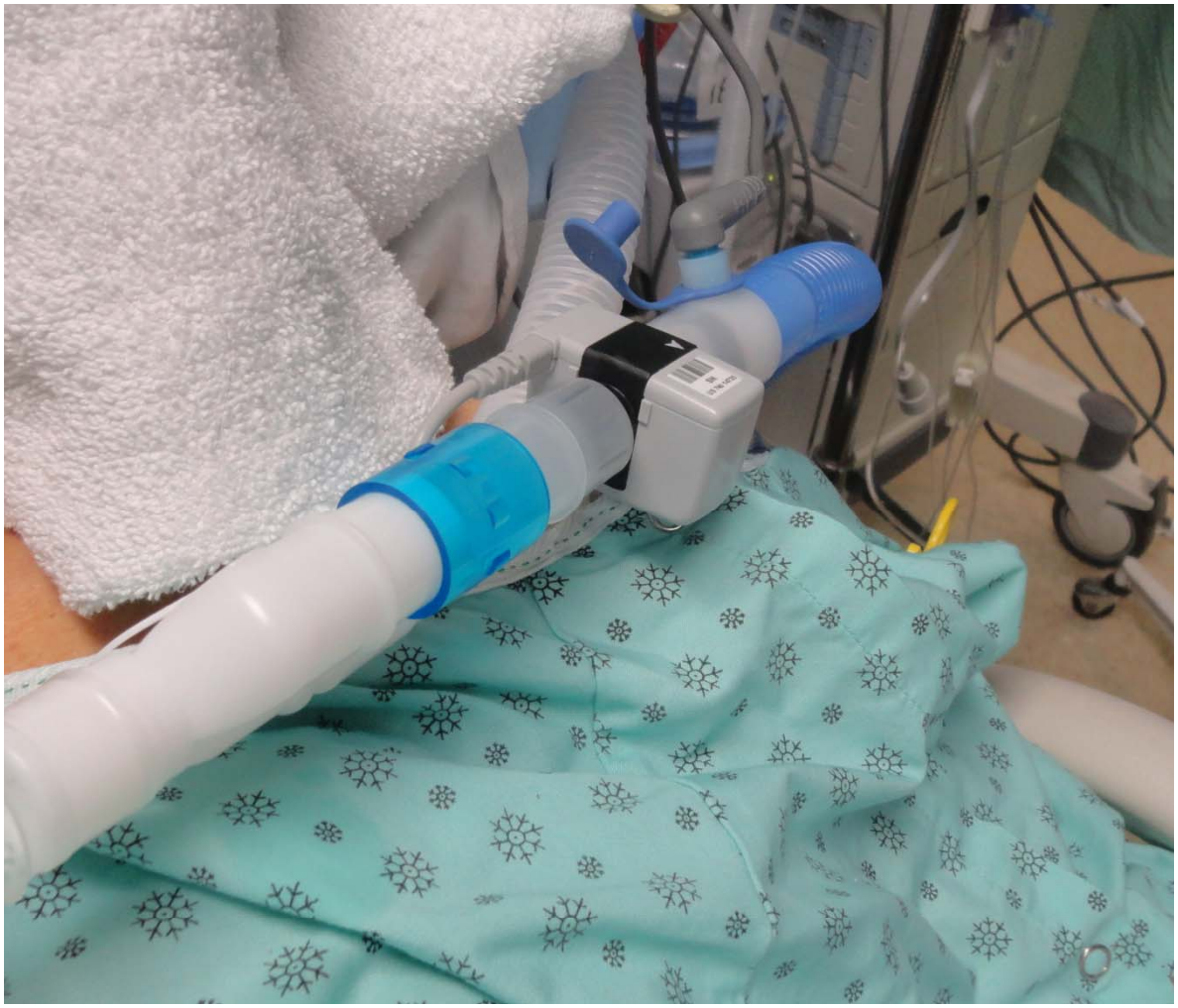


Branche expiratoire

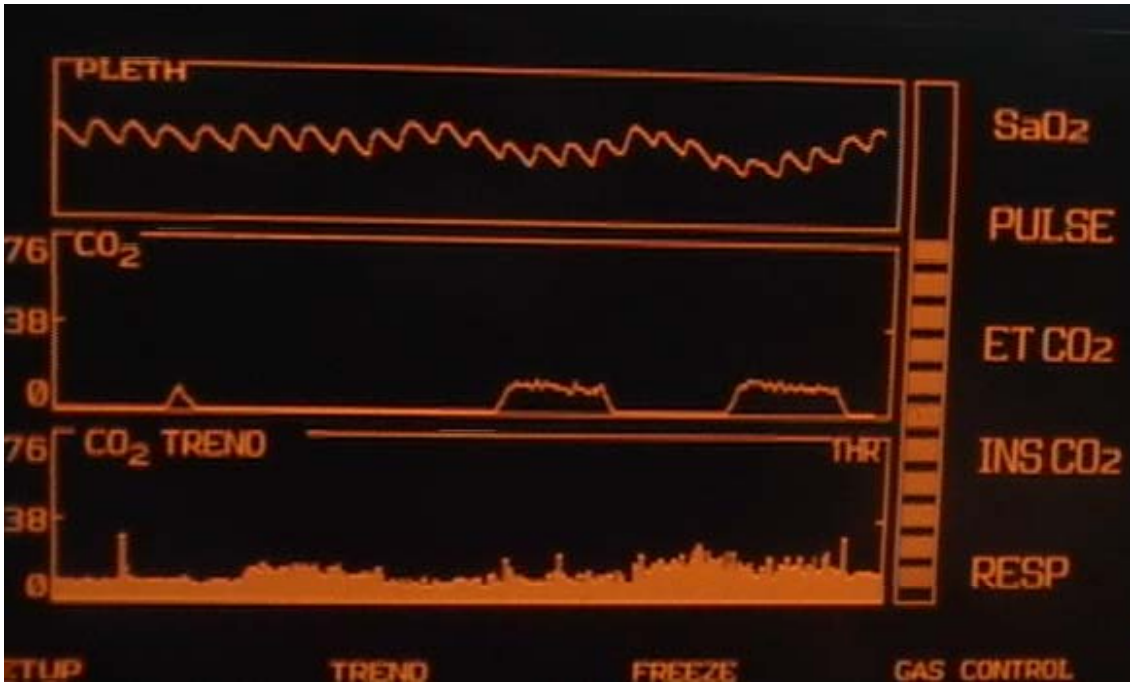
Que se passe-t-il?

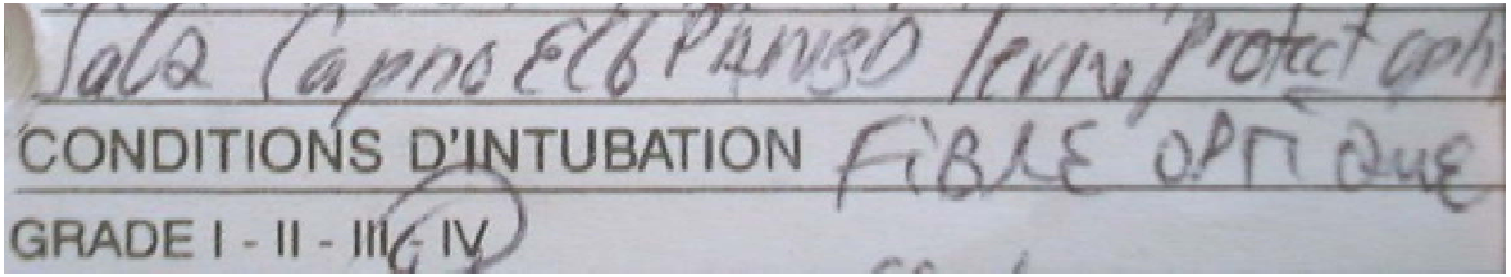


Branche inspiratoire



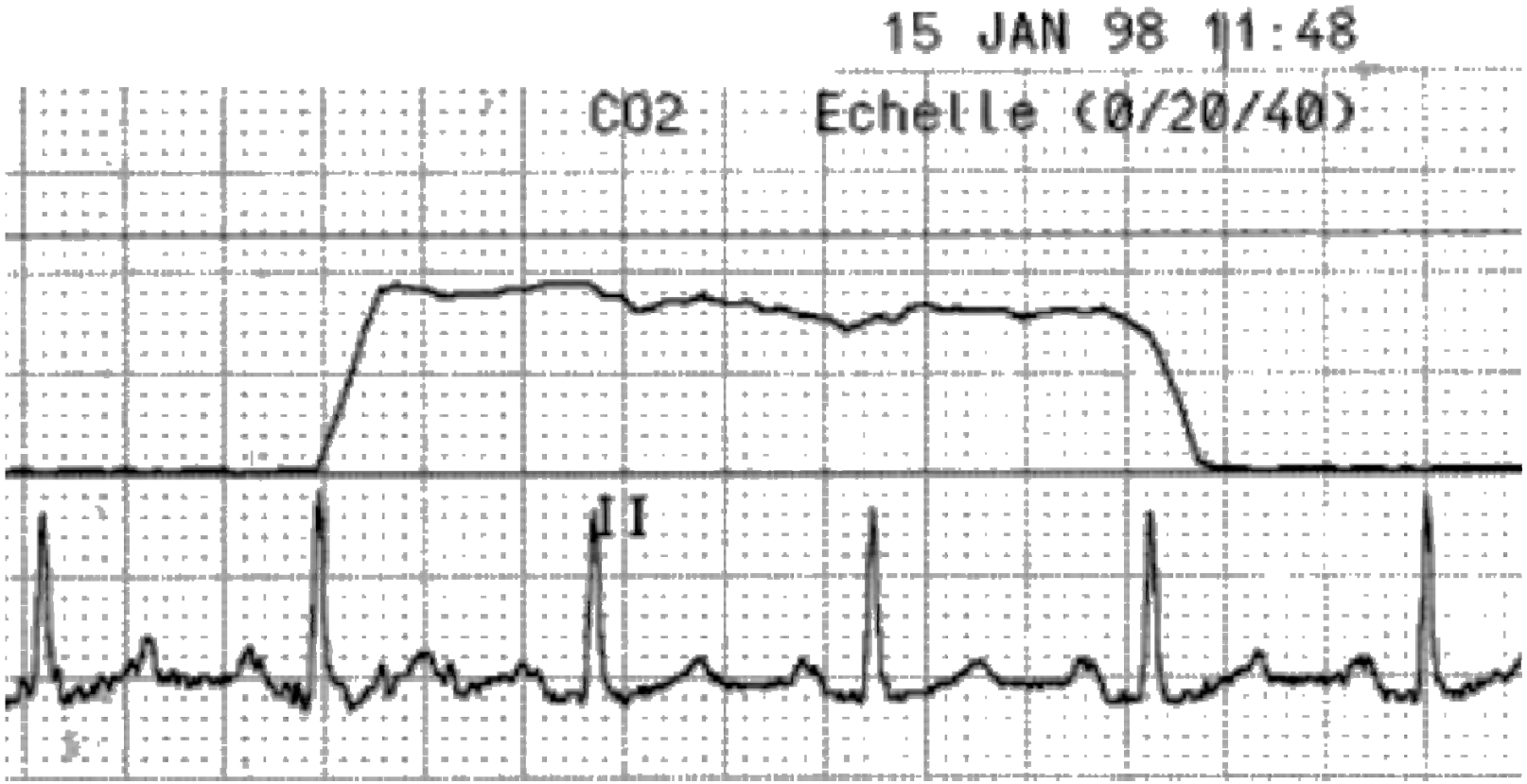
Je suis <u>très</u> inquiet!





Exemple: CHUM-HND un soir….

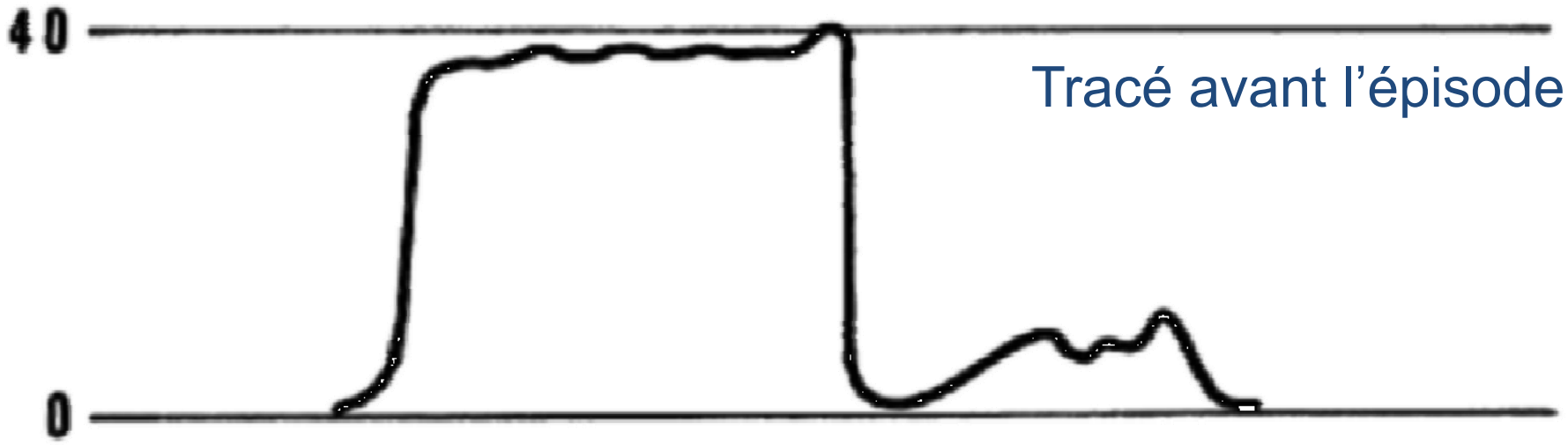
Je suis inquiet!



Échantillonnage central

Explication du tracé?

Désaturation et perte du CO_2 intubation difficile

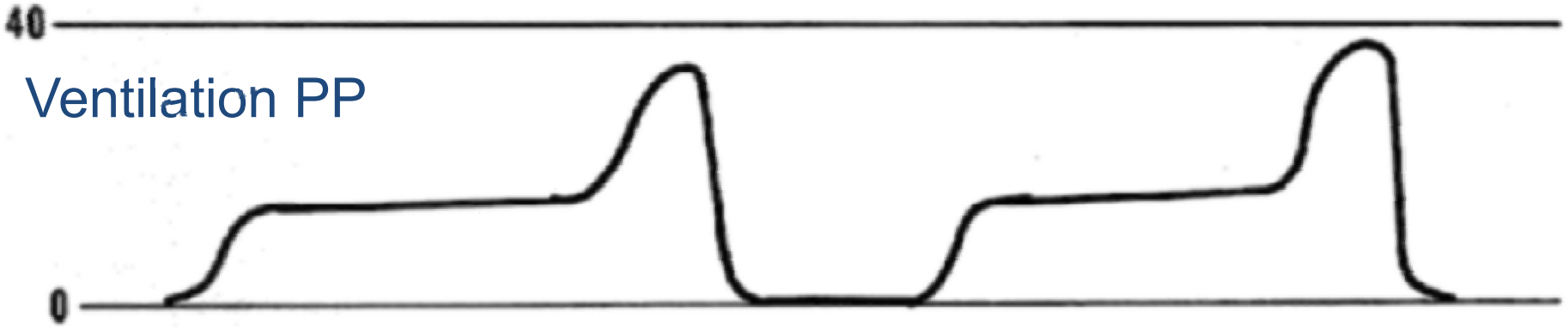


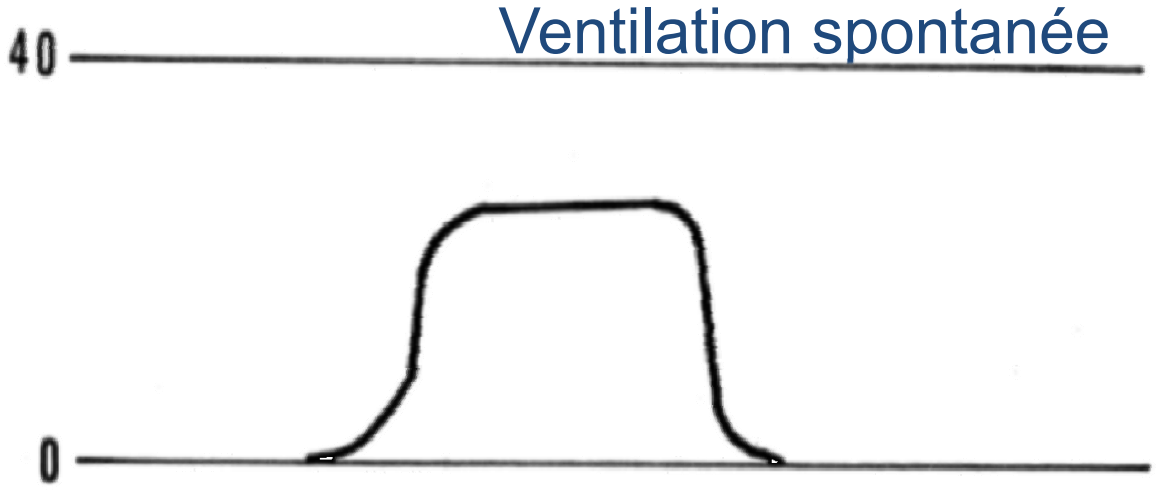
Inquiet?


SpO2
100
90
99
CO2fe
41
CO2mi 0
D.C. 3.98
I.C. 2.01
O2-fe 68
O2-in 75
N2O-fe 0
N2O-in0
ISO-fe0.65
ISO-in0.75
AGT1fe
AGT1in
Début/
Arrêt
PAPO
Débit
Card.
Calculs
Hémo
Tendces
Vitaux
Tendces
Graph.

Ballonnet dégonflé ou TET au niveau cordes vocales

Exemple: HMR un soir….





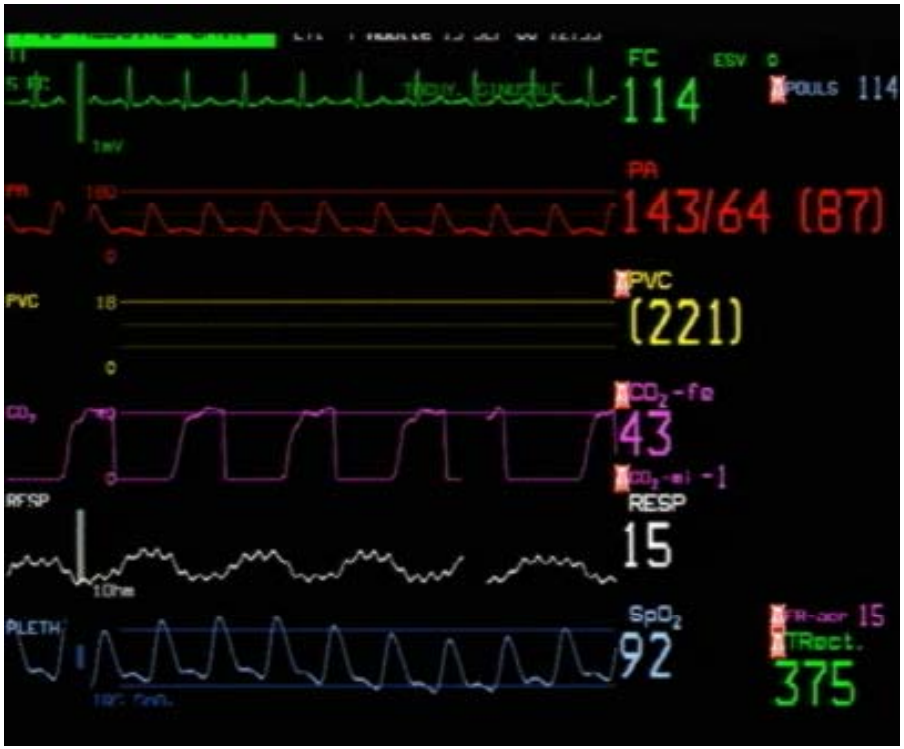
Quel est le problème?

Solution?

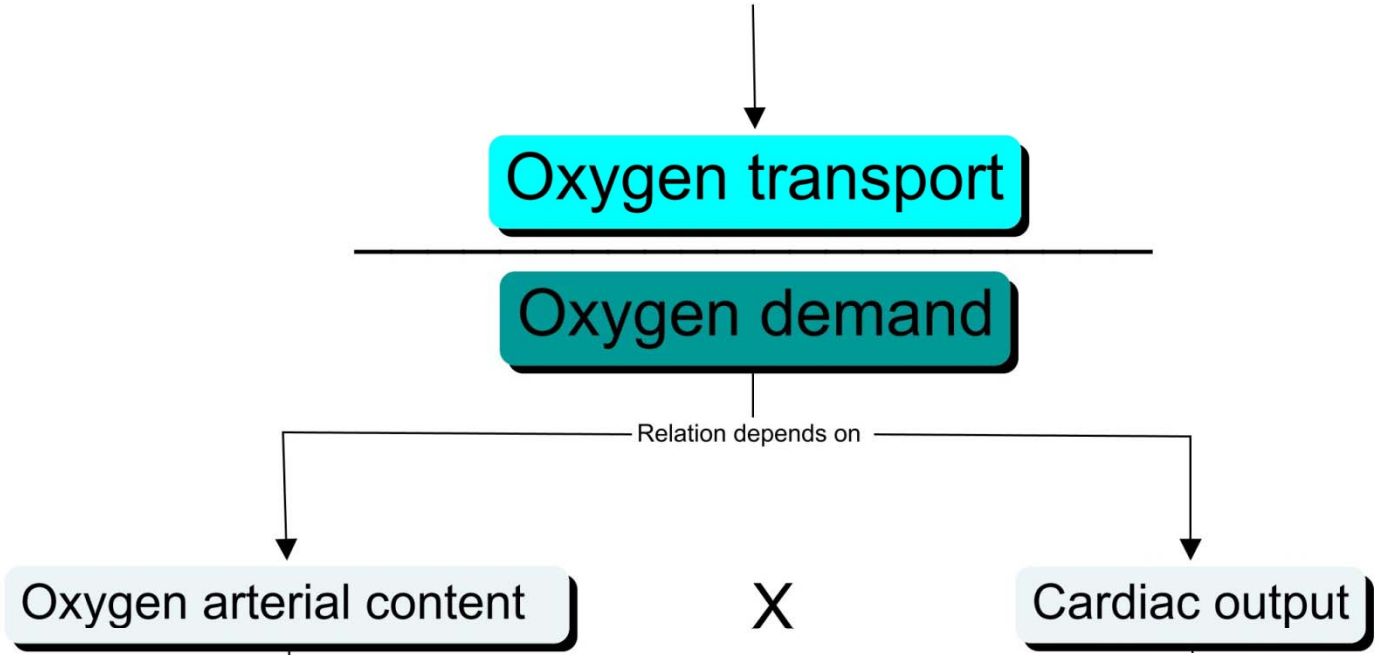

Dellas Nick
Lit 6 Adulte 27 OCT 02 17:00
FC
75
Mode non-stimulé
POULS 74
PA
129/66 (88)
CO2
60
0
CO2-fe
46
CO2-mi 0
PLETH
SpO2
97
RESP
10Ohm
FR-aer 15

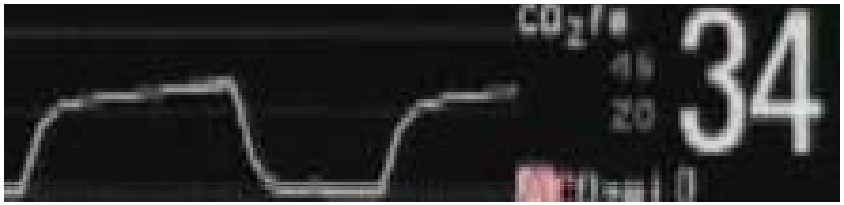
Comment expliquer?

Pourquoi la pression artérielle et le CO_2 expiré sont plus basses?

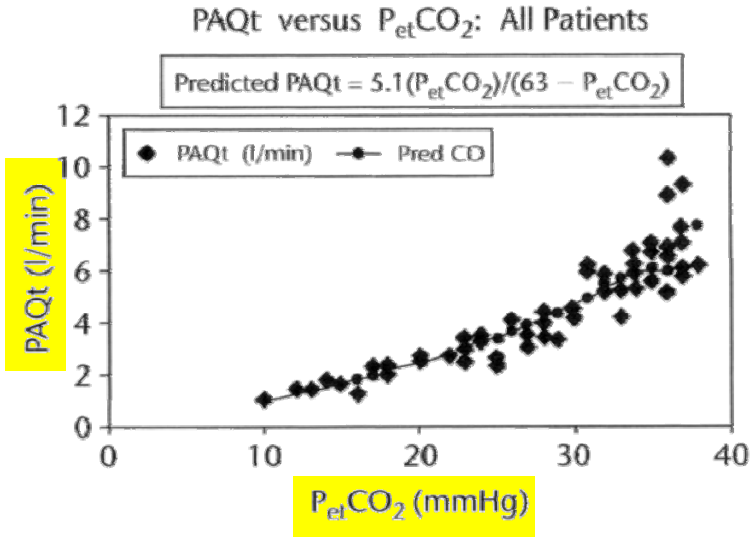


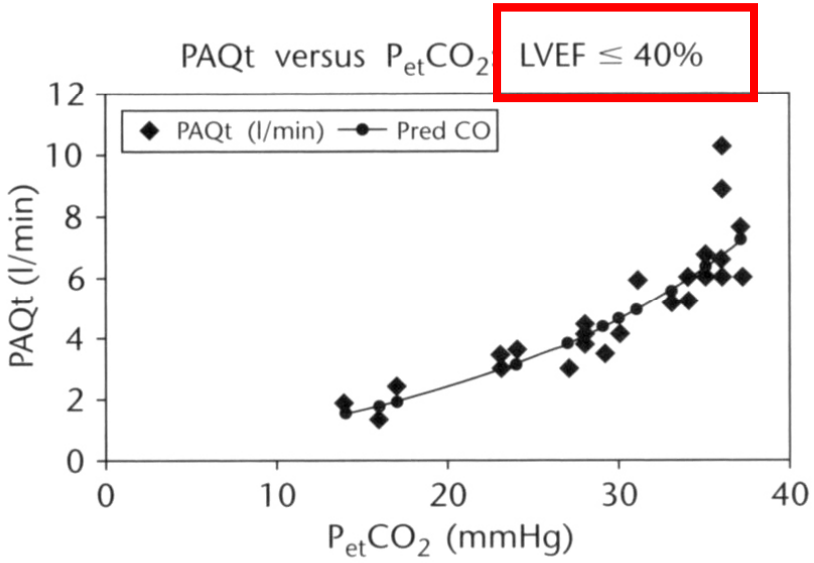
Hypoxia and hemodynamic instability

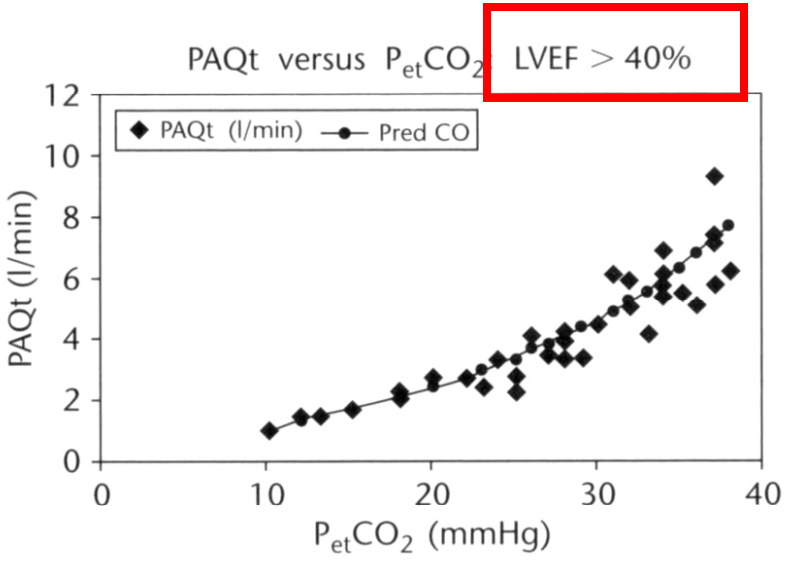




Capnography and cardiac output







Maslow et al Anesth Analg 2001;92:306-313

Moniteur de débit cardiaque

$$VR = \frac{\text{Pressure gradient}}{\text{Resistance}}$$

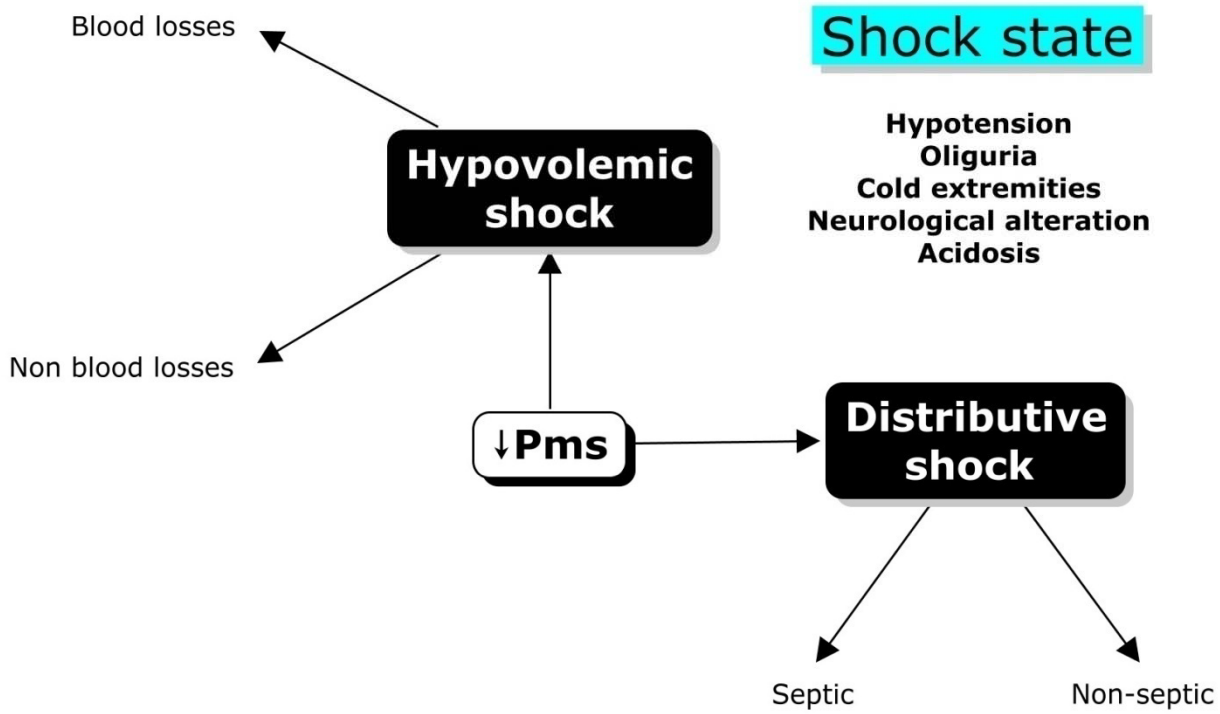
1-↓ Pms: hypovolemia, vasodilatation

2-↑ Pra: Left and right systolic dysfunction
Left and right diastolic dysfunction
Left and right outflow tract obstruction
Pulmonary emboli
Hypoxia and hypercapnia

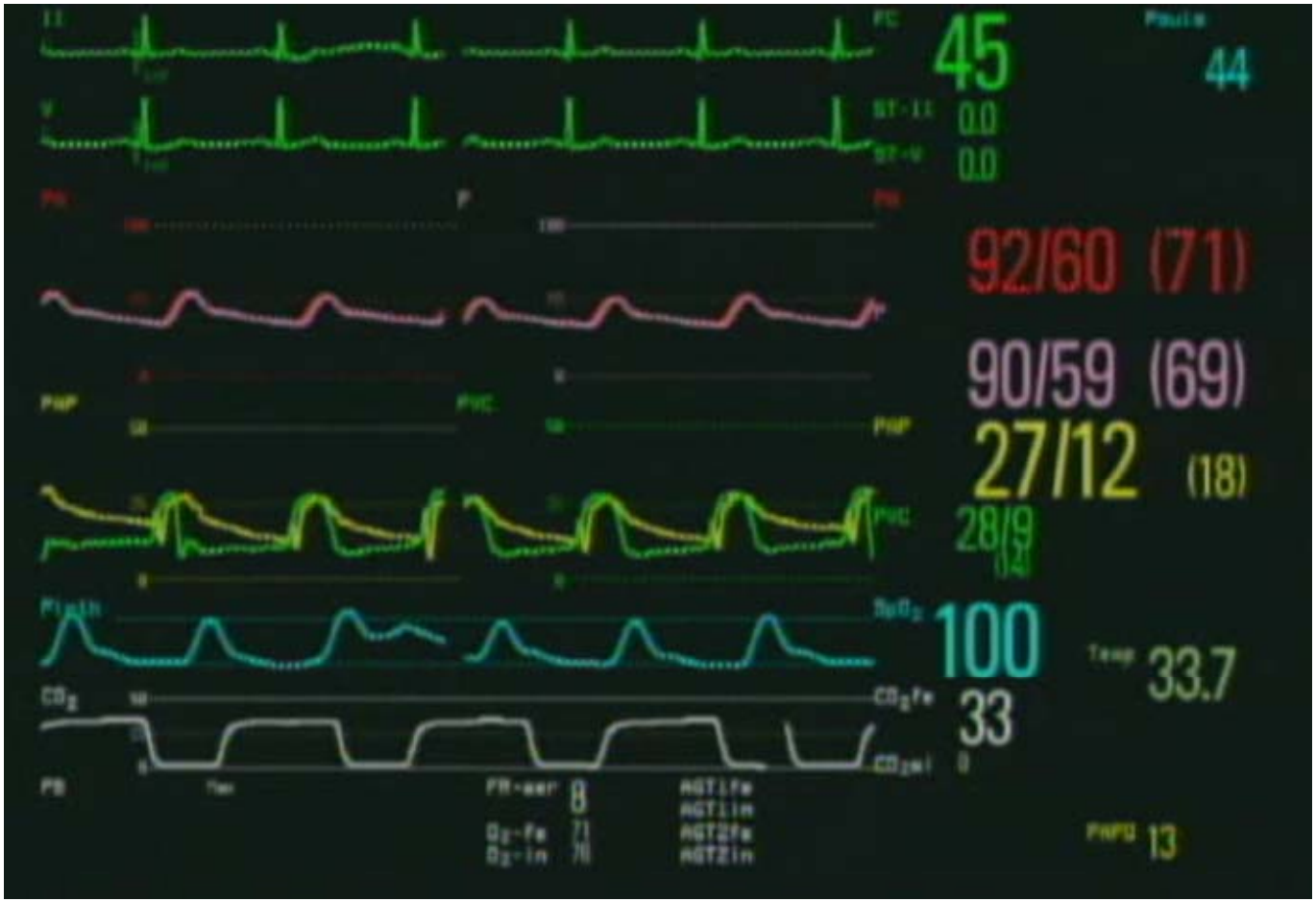
3-↑ Rrv: intrinsic obstruction and compartment syndrome (pericardial, mediastinal, thoracic, abdominal)

Shock state

Hypotension
Oliguria
Cold extremities
Neurological alteration
Acidosis

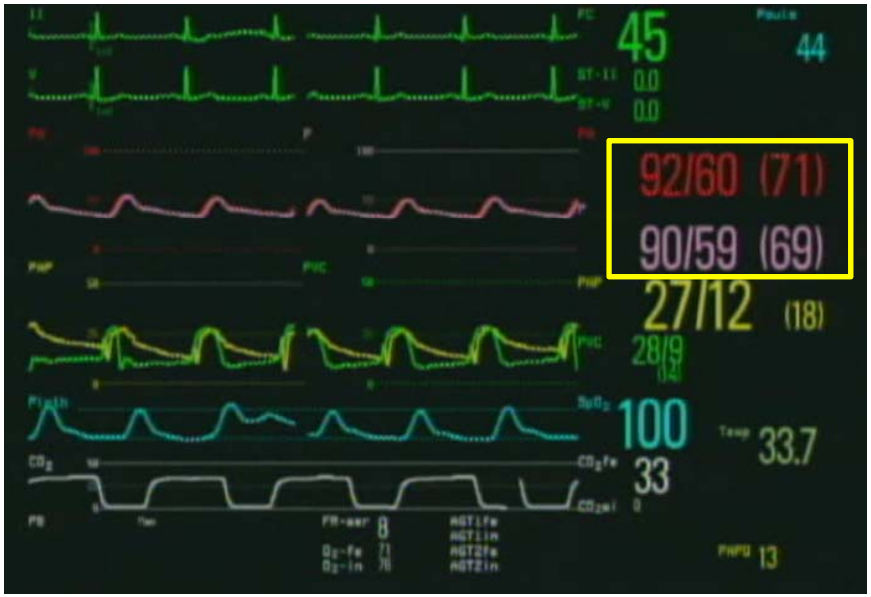

Blood losses
Shock state
Hypovolemic shock
Hypotension
Oliguria
Cold extremities
Neurological alteration
Acidosis
Non blood losses
↓Pms
Distributive shock
Septic
Non-septic

Is this patient fluid responsive?




COMPAQ
Bell

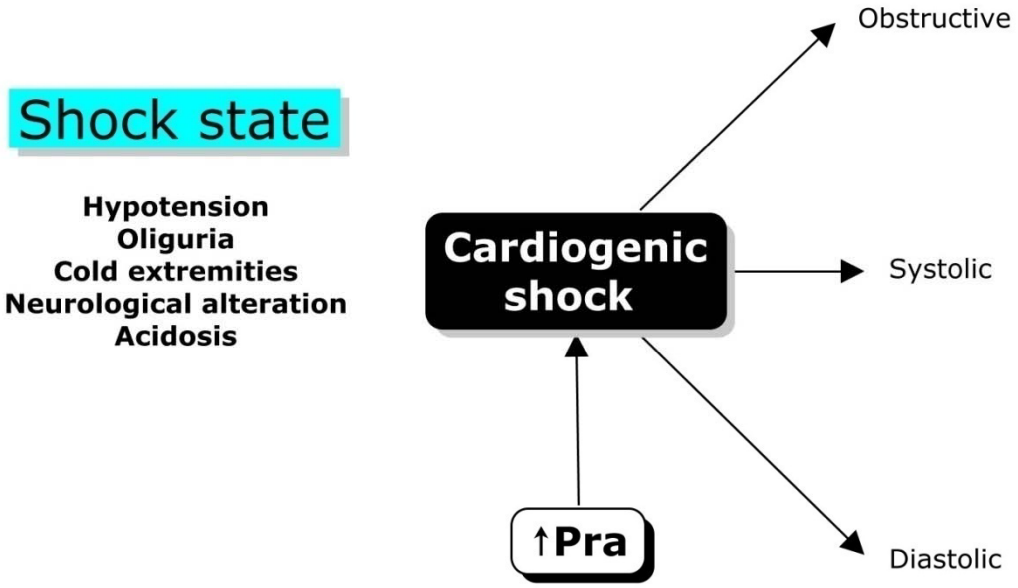
Before



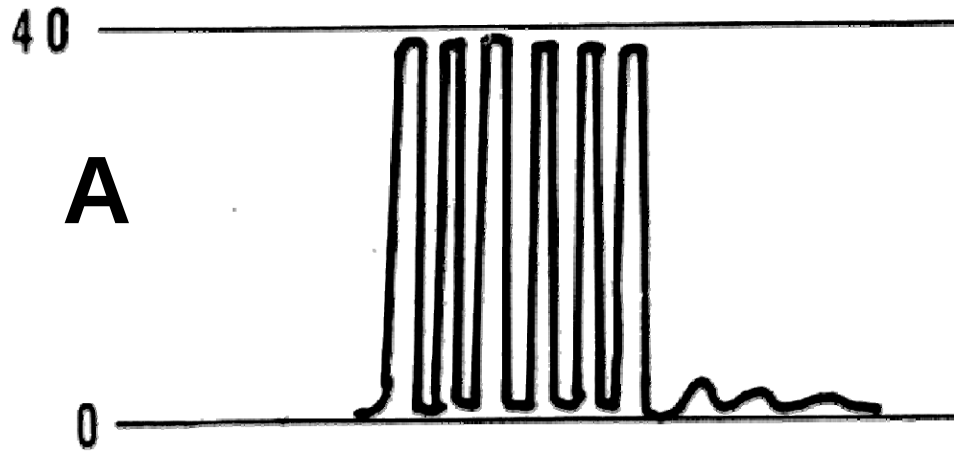
After

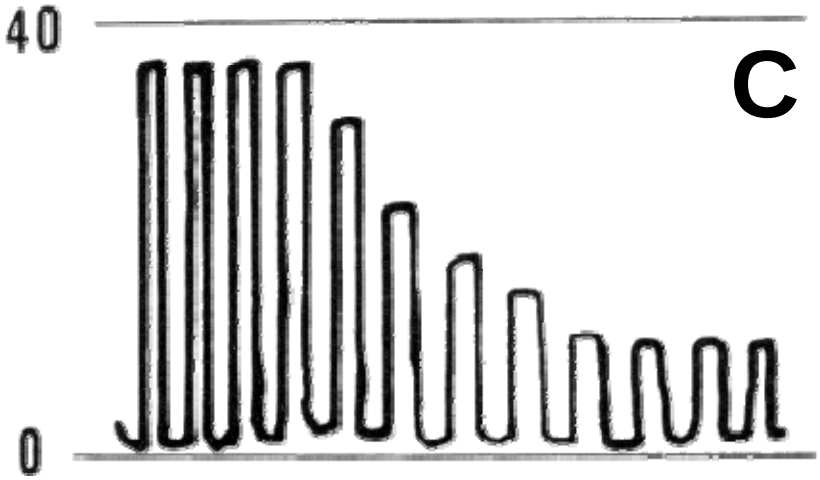
Quel type de choc?

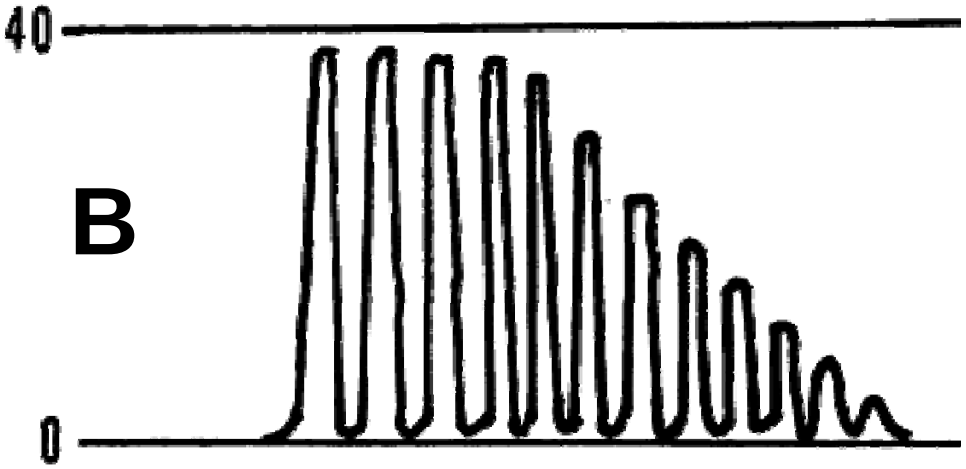
Sevrage de la CEC

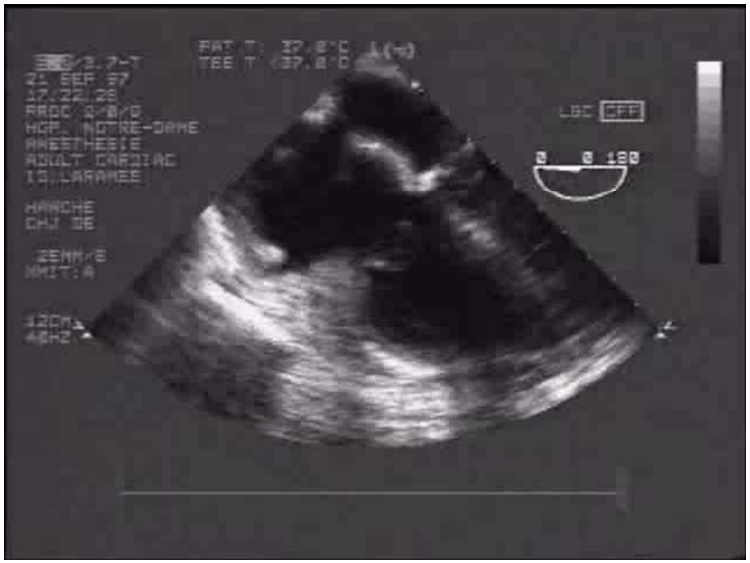

Shock state
Hypotension
Oliguria
Cold extremities
Neurological alteration
Acidosis
Cardiogenic shock
Obstructive
Systolic
Diastolic
↑Pra

Exemple: prothèse de genou:↓TA après relâche du garrot

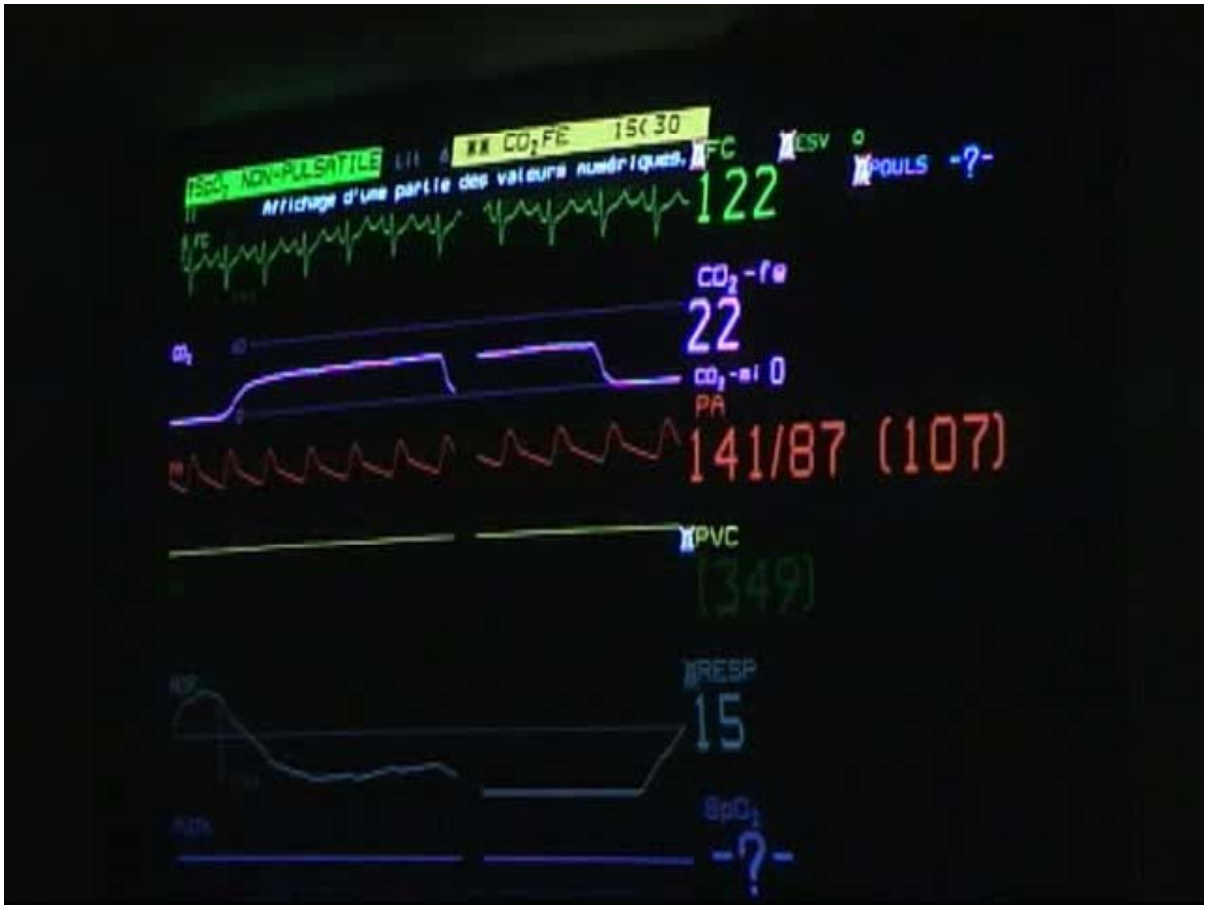






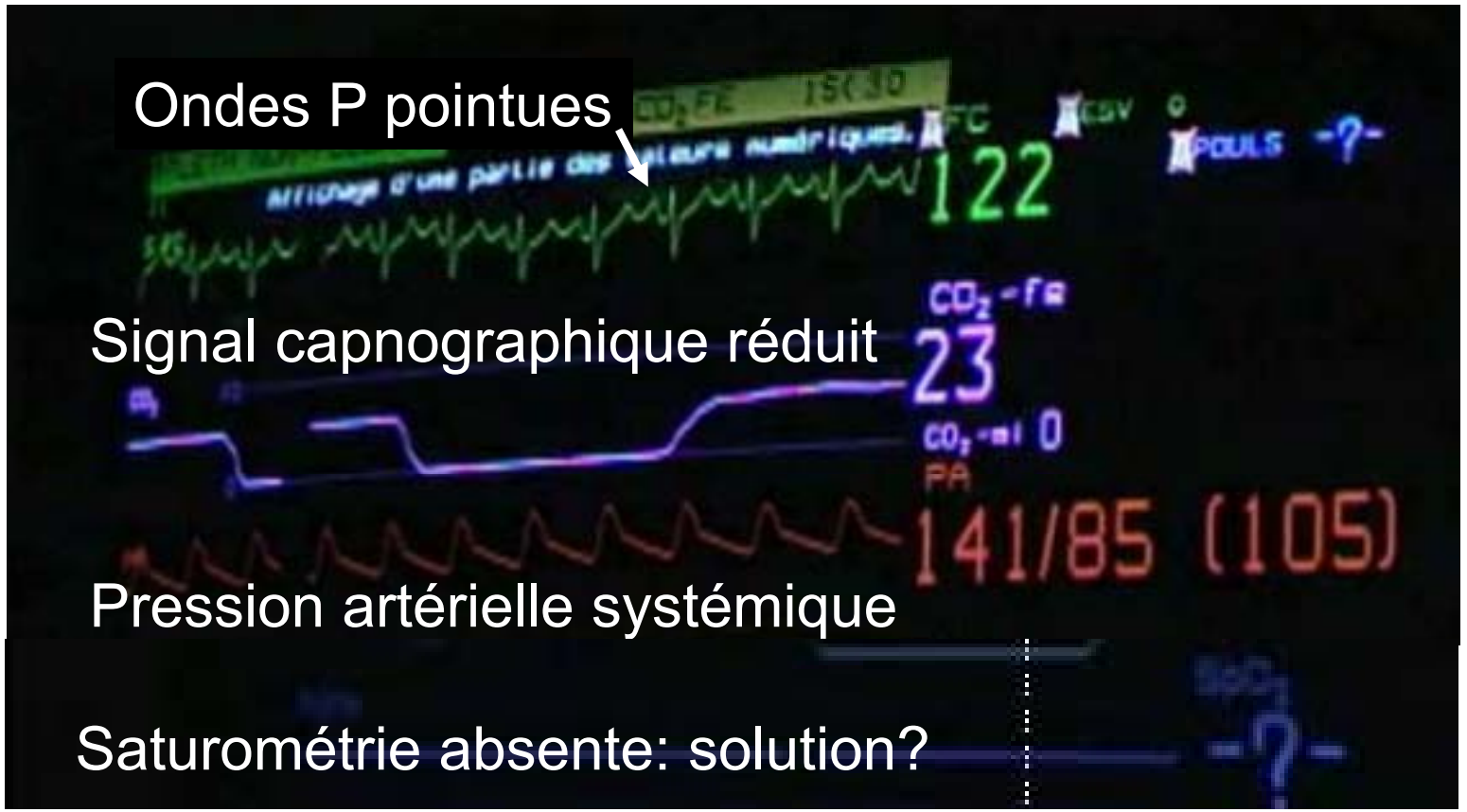


Hypotendu à l'urgence
3 semaines après chirurgie pour méningiome.



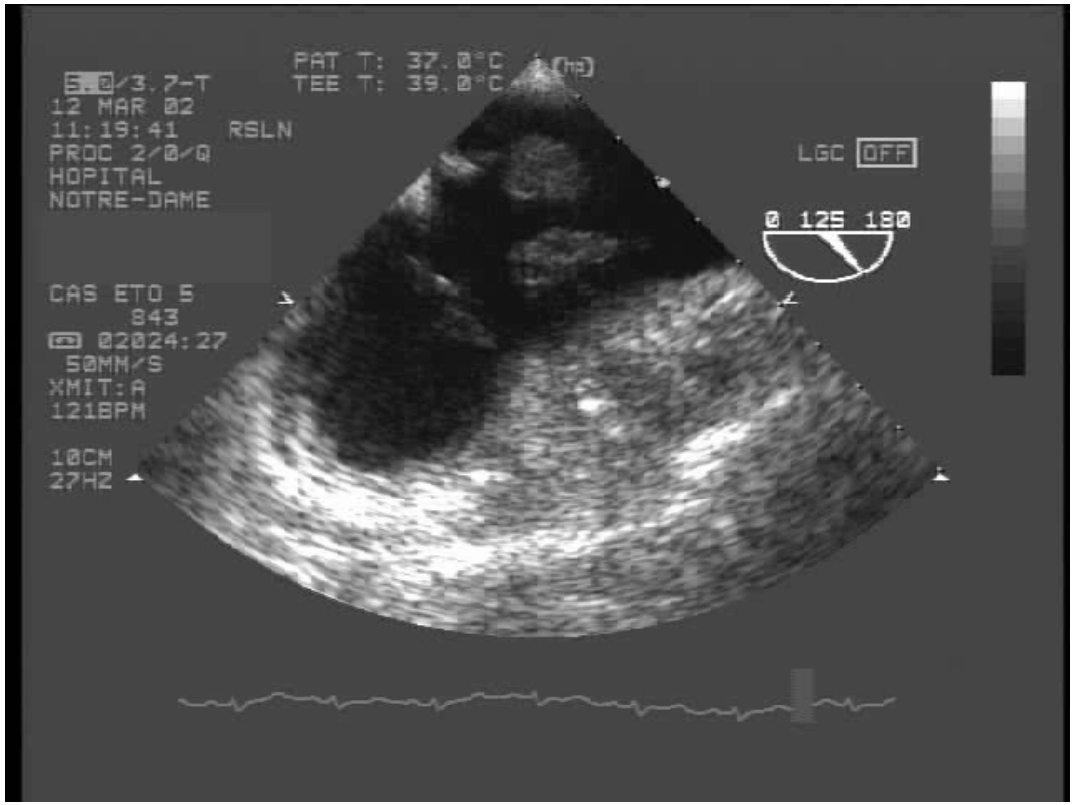
Noradrénaline à 0.15 µg/kg/min
(40 ml/h de 4mg/250ml)

Hypotendu à l'urgence
3 semaines après chirurgie pour méningiome.

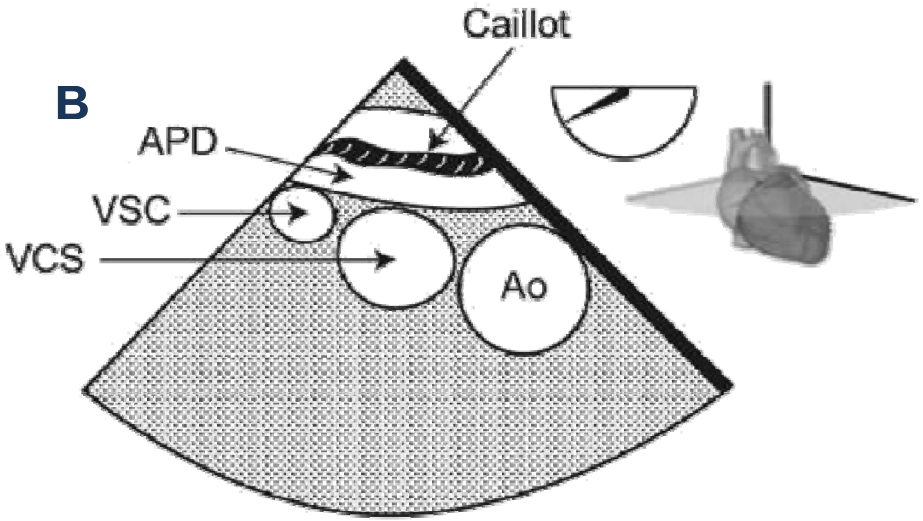


Noradrénaline à 0.15 µg/kg/min
(40 ml/h de 4mg/250ml)

Hypotendue à l'urgence
3 semaines après chirurgie pour méningiome.

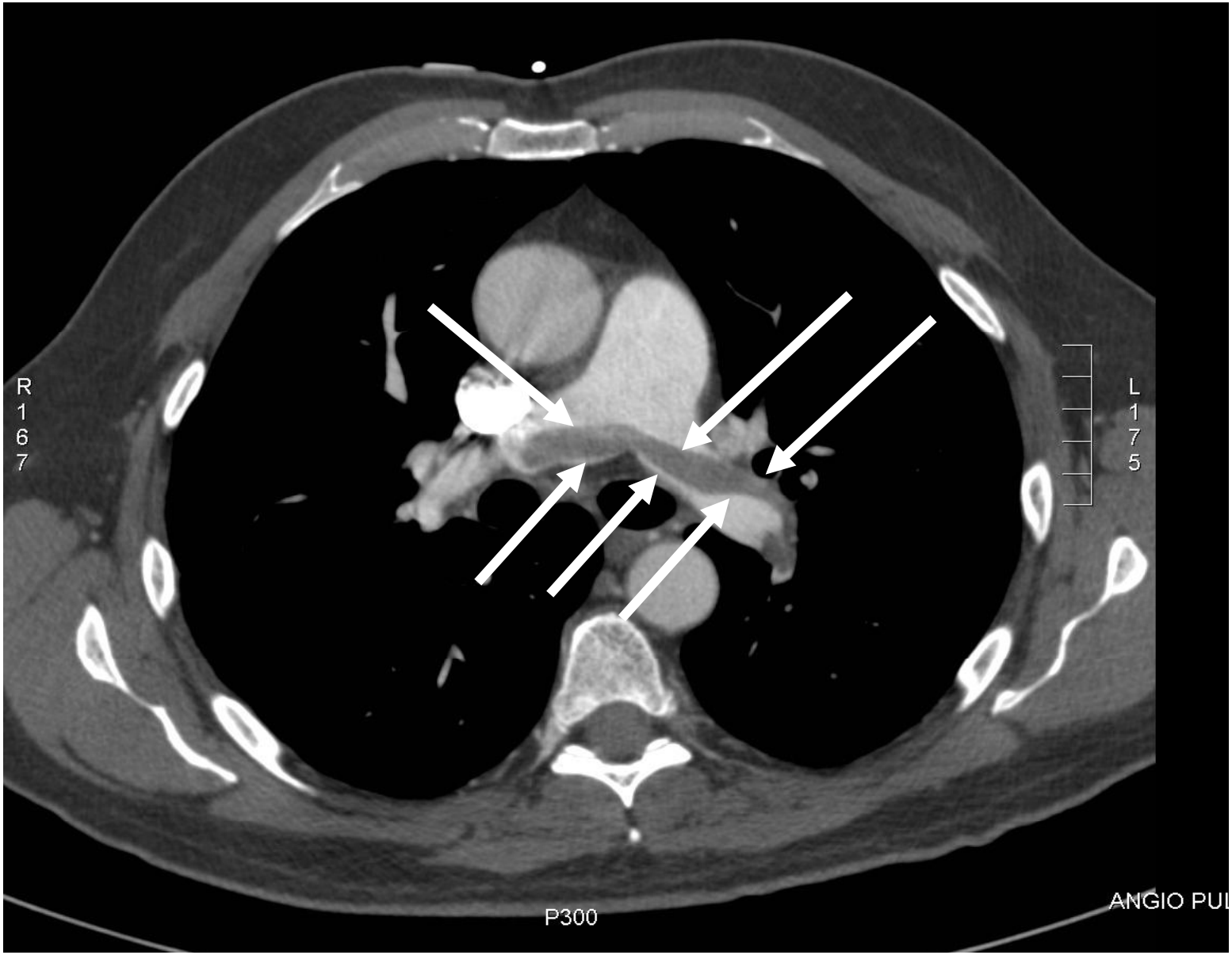


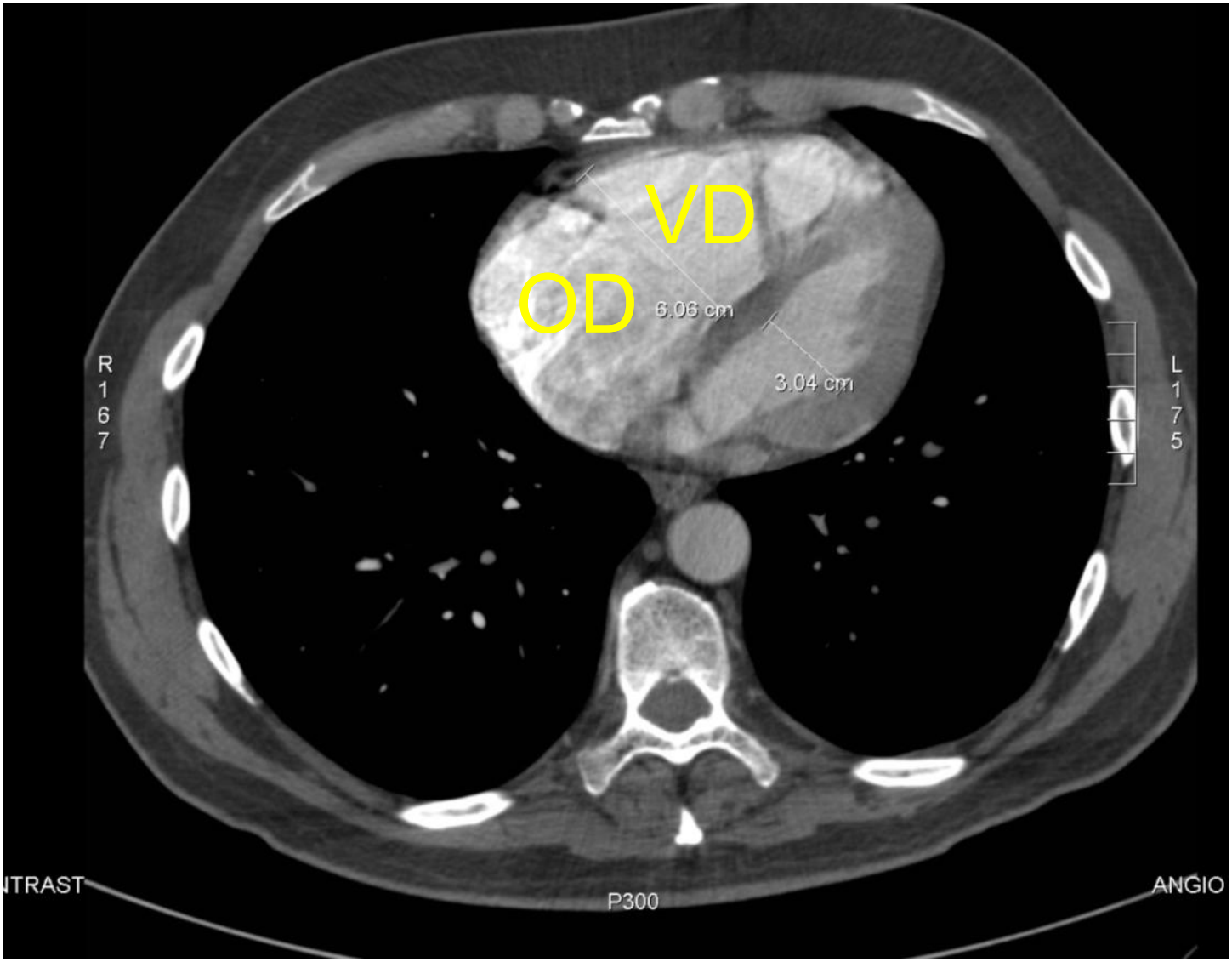
Noradrénaline à 0.15 µg/kg/min
(40 ml/h de 4mg/250ml)



Courtoisie Dr David Braco and Dr Nicolas Noiseux

CT-angio




VD
OD
6.06 cm
3.04 cm
R
1
6
7
L
1
7
5
ITRAST
P300
ANGIO

Bedside end-tidal CO_2 tension as a screening tool to exclude pulmonary embolism

A.R. Hemnes*, A.L. Newman*, B. Rosenbaum#, T.W. Barrett¶, C. Zhou+, T.W. Rice* and J.H. Newman*

TABLE 5 Test performance characteristics

	Sensitivity	Specificity	PPV	NPV
P_{ET,CO_2} <36 All Comers	87.2 (73.3–94.4)	53.0 (47.0–58.8)	21.1 (15.5–28.1)	96.6 (92.3–98.5)
P_{ET,CO_2} <36 excluding >44	91.9 (78.7–97.2)	49.0 (42.8–55.2)	21.1 (15.5–28.1)	97.6 (93.2–99.2)
Wells Score ⩾4	61.5 (45.9–75.1)	83.3 (78.4–87.3)	34.8 (24.6–46.6)	93.8 (89.9–96.2)
P_{ET,CO_2} <36 All Comers + Wells Score ⩾4	92.3 (79.7–97.3)	45.2 (39.4–51.1)	19.6 (14.5–25.9)	97.6 (93.2–99.2)

Data are presented as % (95% CI). PPV: positive predictive value; NPV: negative predictive value. P_{ET,CO_2}: end-tidal carbon dioxide tension.

A P_{ET,CO_2} of ⩾36 mmHg may reliably exclude PE. Accuracy is augmented by combination with Wells score. P_{ET,CO_2} should be prospectively compared to D-dimer in accuracy and simplicity to exclude PE.

Eur Respir J. 2010 Apr;35(4):735-41. Epub 2009 Aug 28.

The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

MEDICAL PROGRESS

Acute Pulmonary Embolism

Victor F. Tapson, M.D.

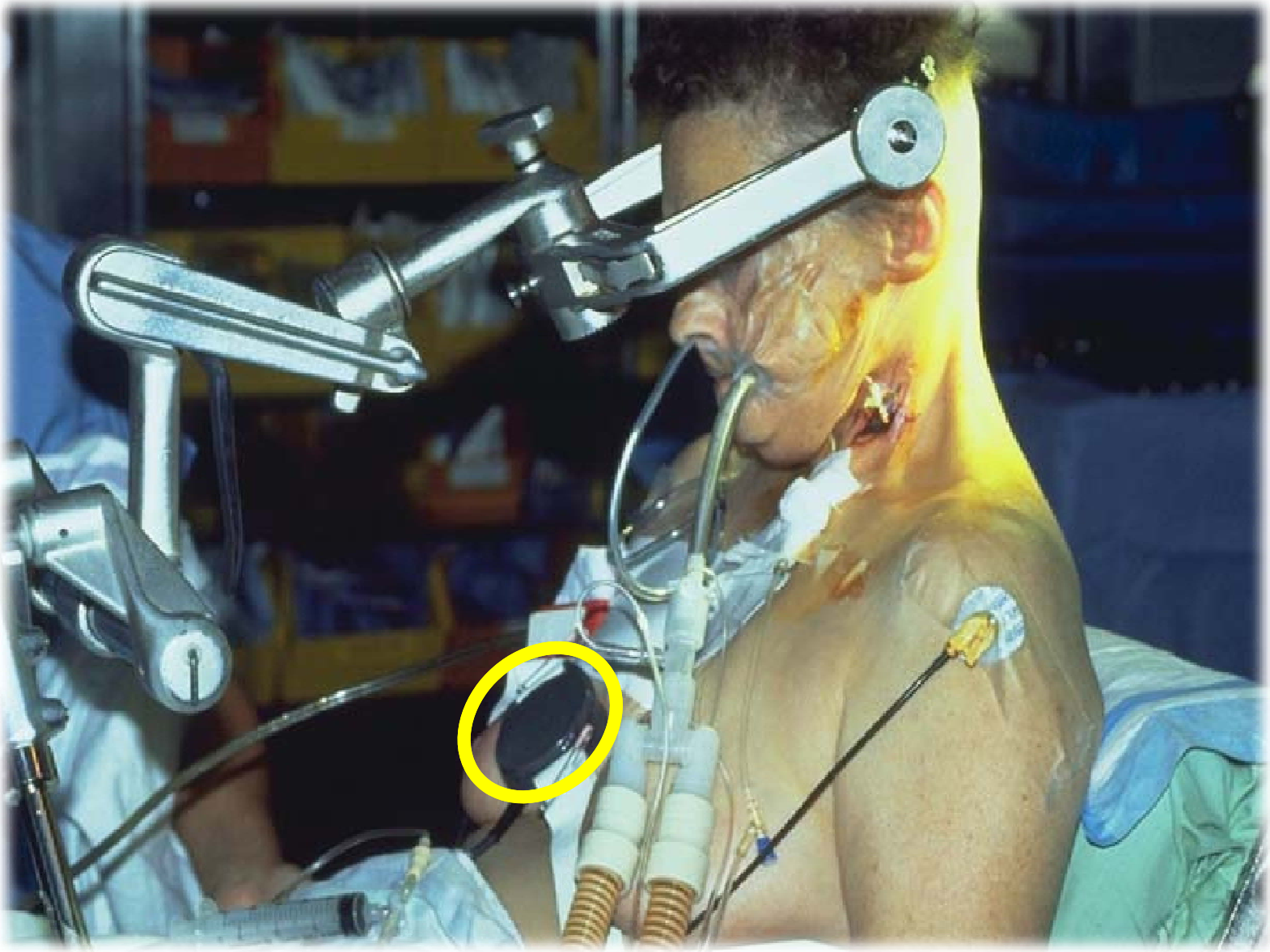
Table 2. Clinical Prediction Scores for Suspected Acute Pulmonary Embolism.*

Canadian (Wells) prediction score

Variable and score

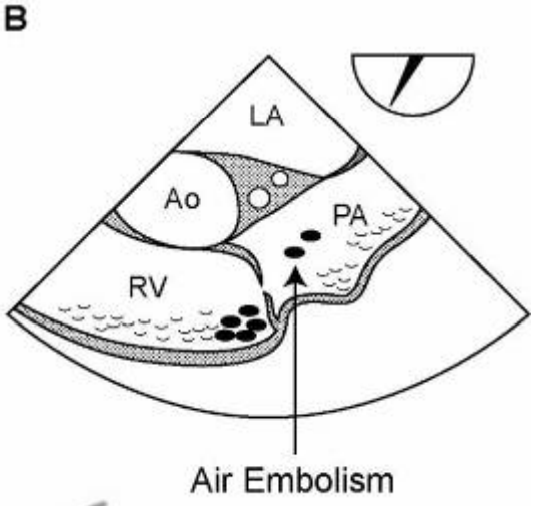
- DVT symptoms and signs — 3.0
- PE as likely as or more likely than alternative diagnosis — 3.0†
- Heart rate >100 beats/min — 1.5
- Immobilization or surgery in previous 4 wk — 1.5
- Previous DVT or PE — 1.5
- Hemoptysis — 1.0
- Cancer — 1.0

Chirurgie en position assise



Chirurgie en position assise

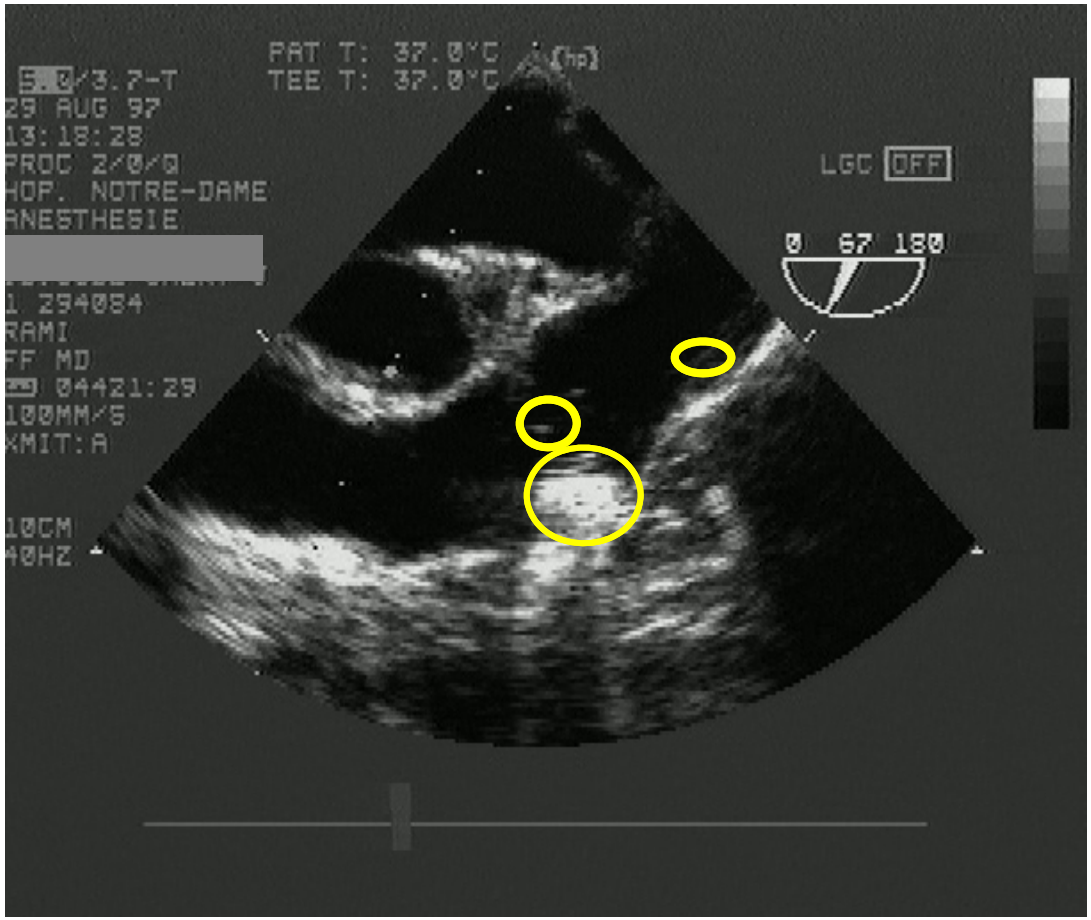
Hypotension lors d'une chirurgie de scoliose en position ventrale



Denault TEE manual 2005

Hypotension lors d'une chirurgie de scoliose en position ventrale

MO ch de chasse VD



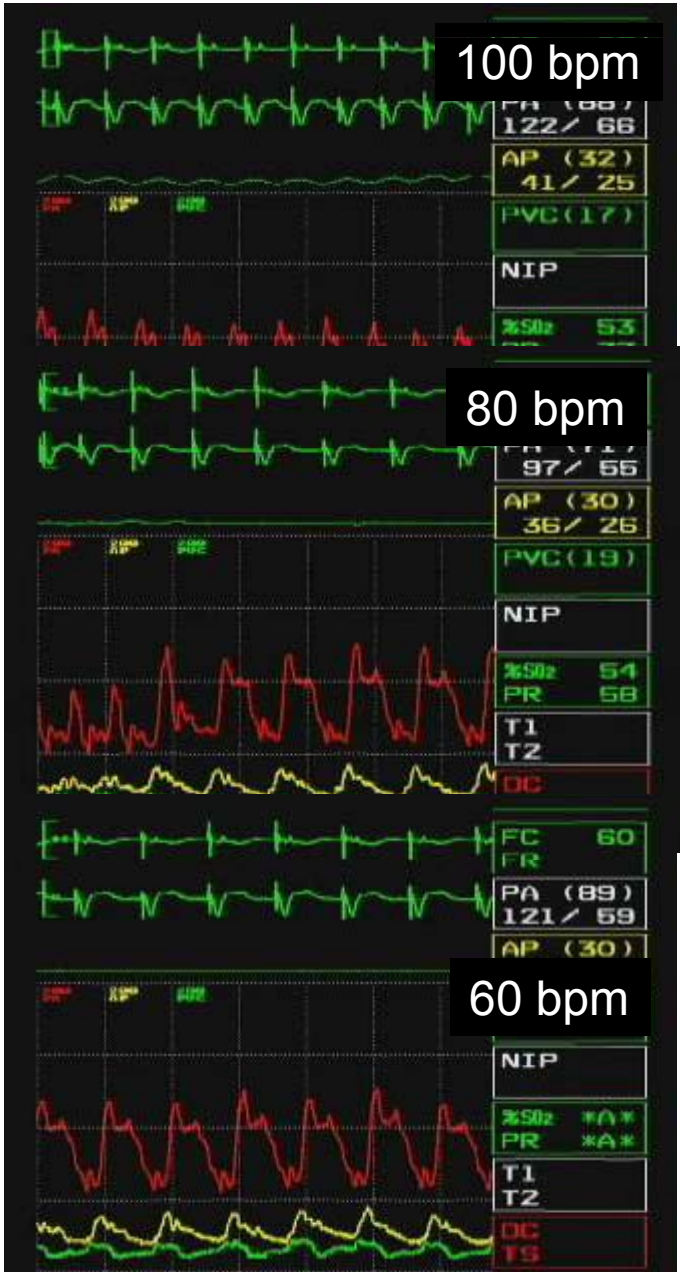
76 yo ♂ after aortic arch replacement

Back in the OR for acute bleeding: paced at 100 per minutes

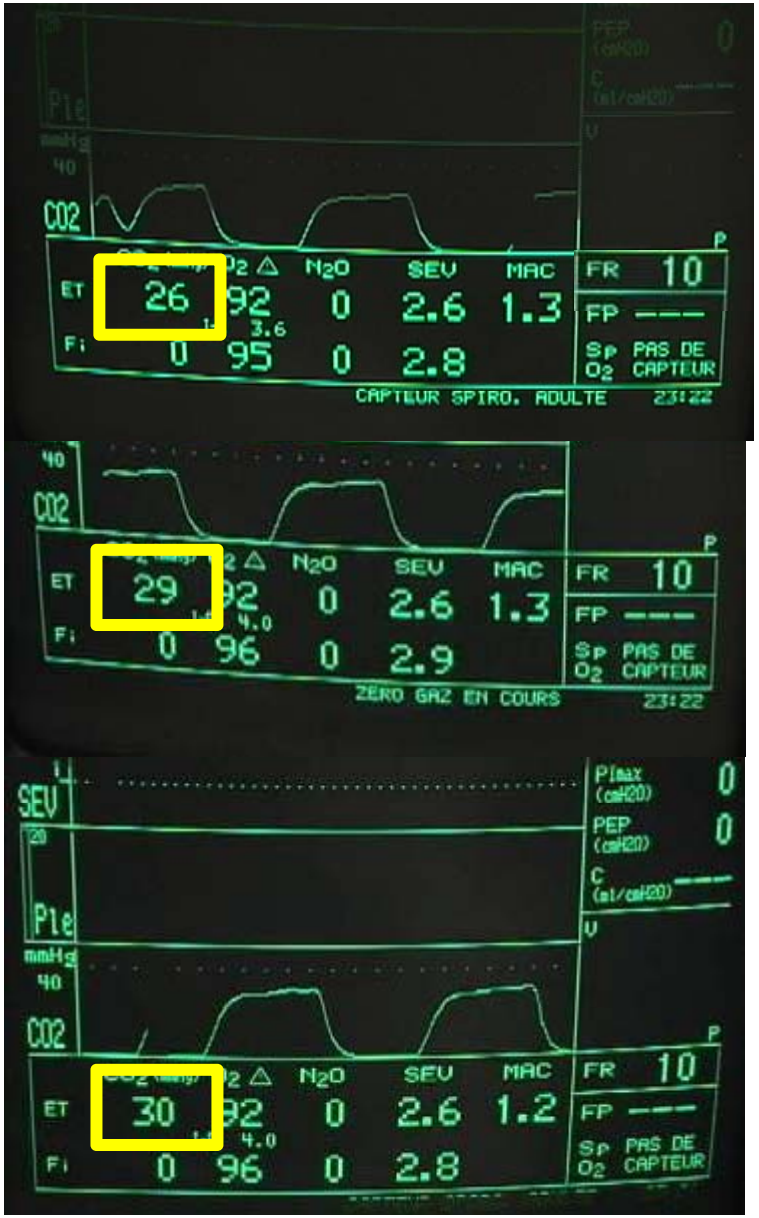
Hemodynamic

$ETCO_2$

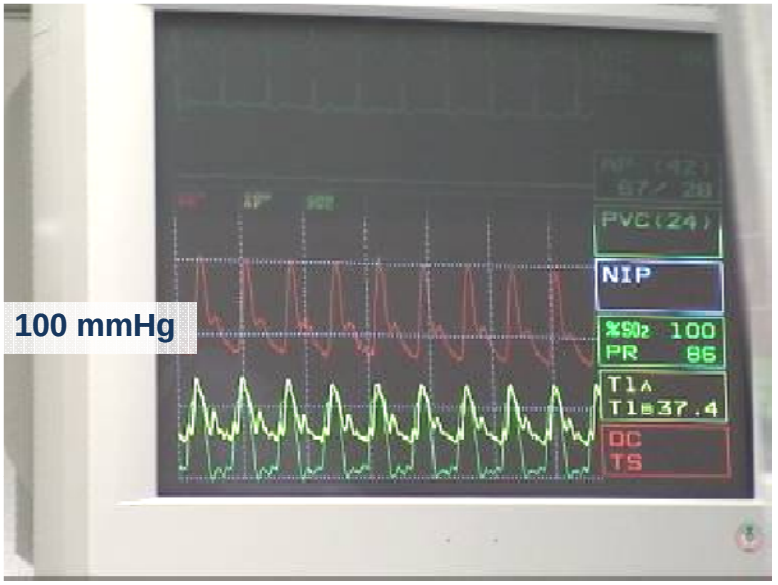
76 yo ♂ after aortic arch replacement



Temporary pacemaker



♂ de 70 ans instable post RVA



Noradrénaline 4ug/min

Noradrénaline 0.5 ug/min

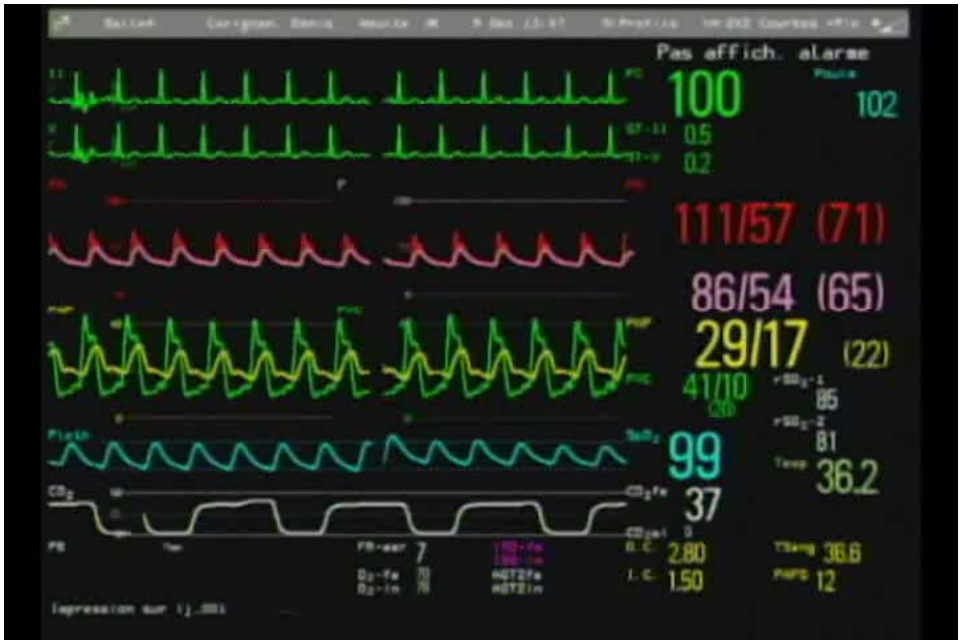
Quelle médication?

Avant

Après

Quelle médication?

Avant

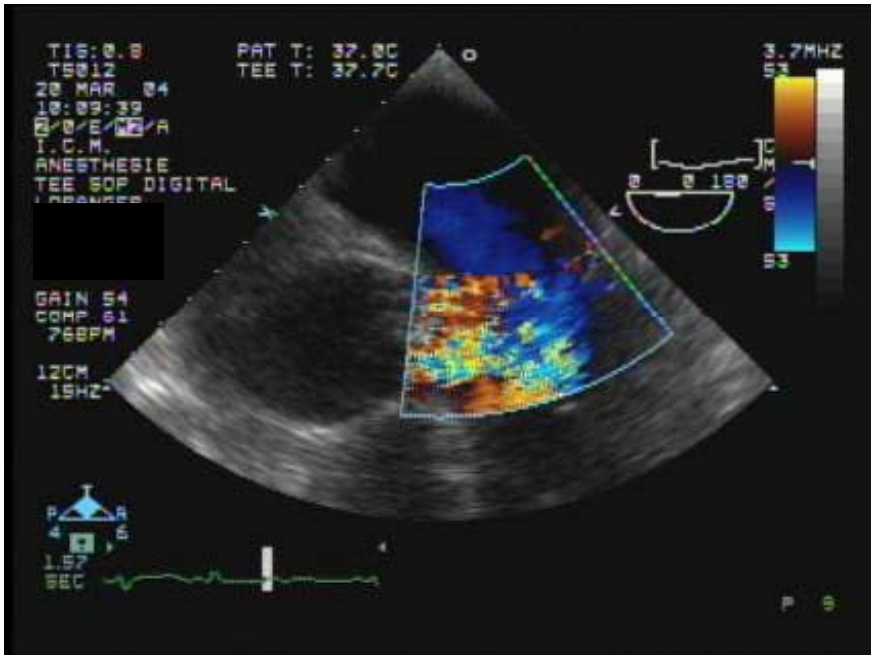


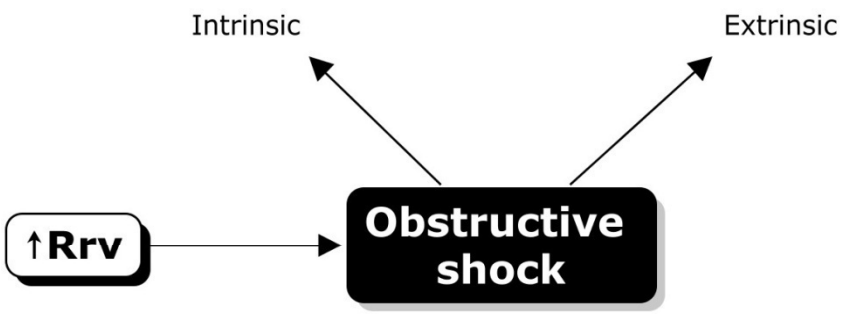
Après

Lopressor 2.5 mg IV

Homme de 61 ans avec régurgitation aortique sur endocardite

	Pré-CEC	**Post-CEC**
Index cardiaque	1.8 L/m/m^2	3.2 L/m/m^2
Fraction d'éjection	20%	40%
ETCO2	31 mmHg	37 mmHg



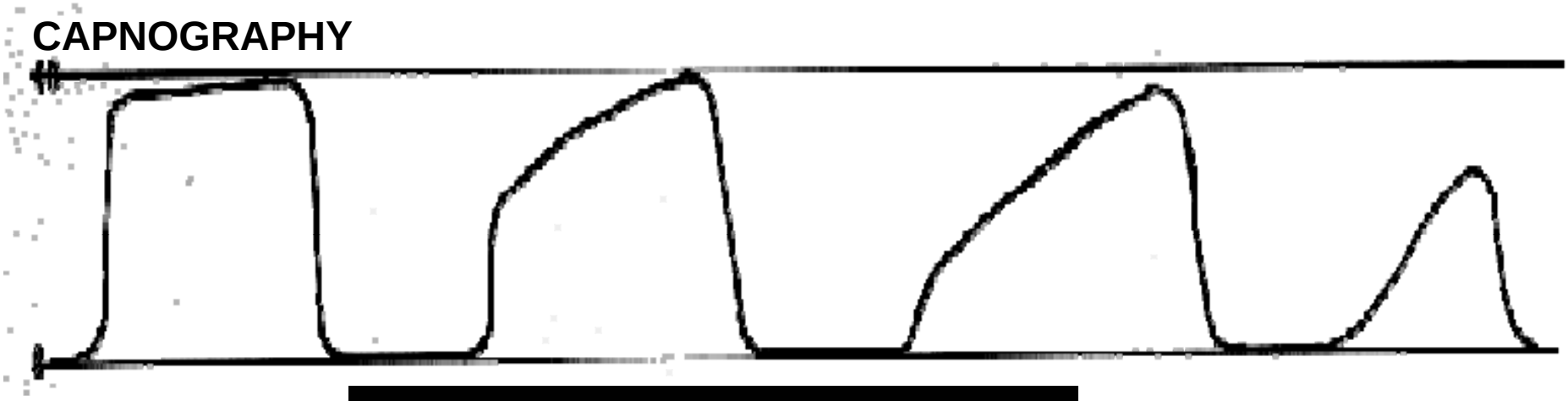


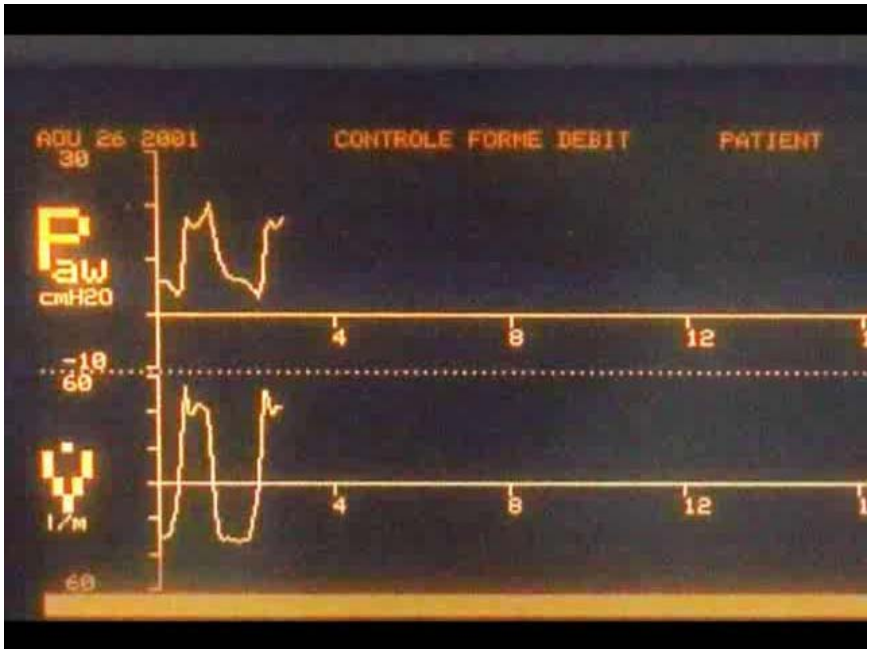
Shock state

Hypotension
Oliguria
Cold extremities
Neurological alteration
Acidosis

Unstable patient in the ICU
Peak pressure ↑ and severe hypotension. Why?

CAPNOGRAPHY





Femme de 56 ans encéphalopathie hypercapnique et hypotendue après introduction de la ventilation mécanique

Femme de 56 ans encéphalopathie hypercapnique et hypotendue après introduction de la ventilation mécanique

Femme de 56 ans encéphalopathie hypercapnique et hypotendue après introduction de la ventilation mécanique

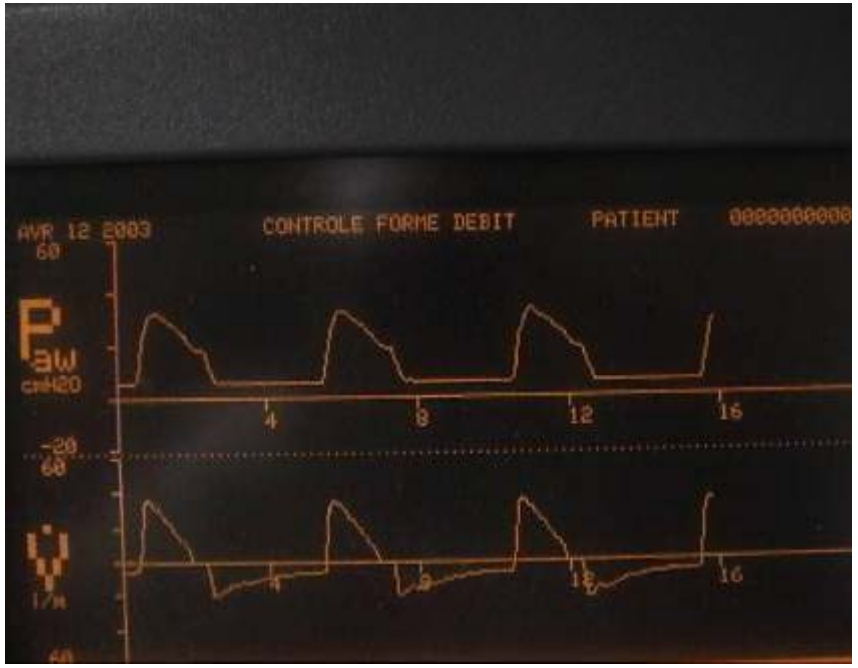
Femme de 56 ans encéphalopathie hypercapnique et hypotendue après introduction de la ventilation mécanique

Au début

Post bronchodilatation et scopie

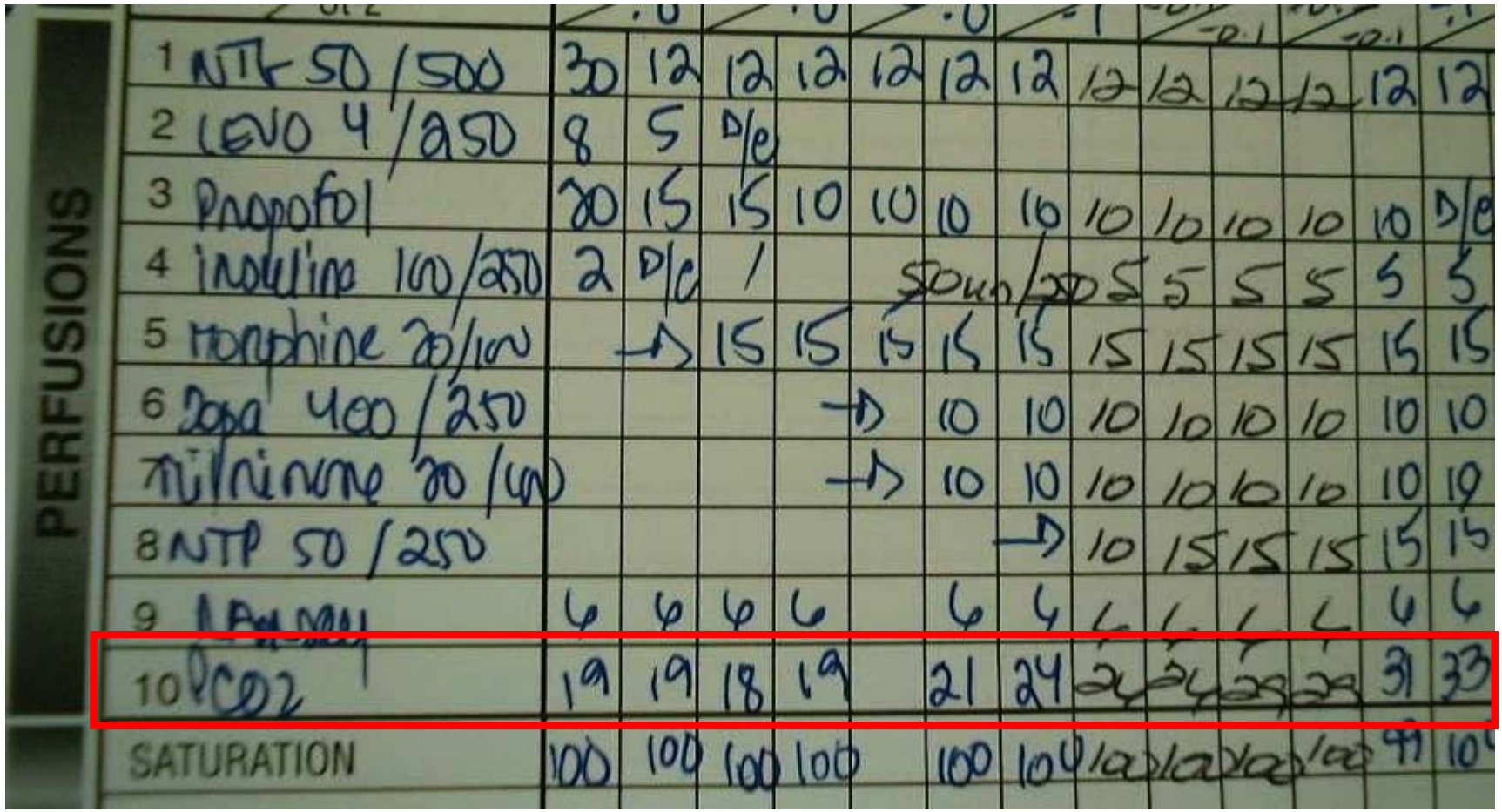
Homme de 69 ans MPOC

Homme de 68 ans MPOC



Autres exemples

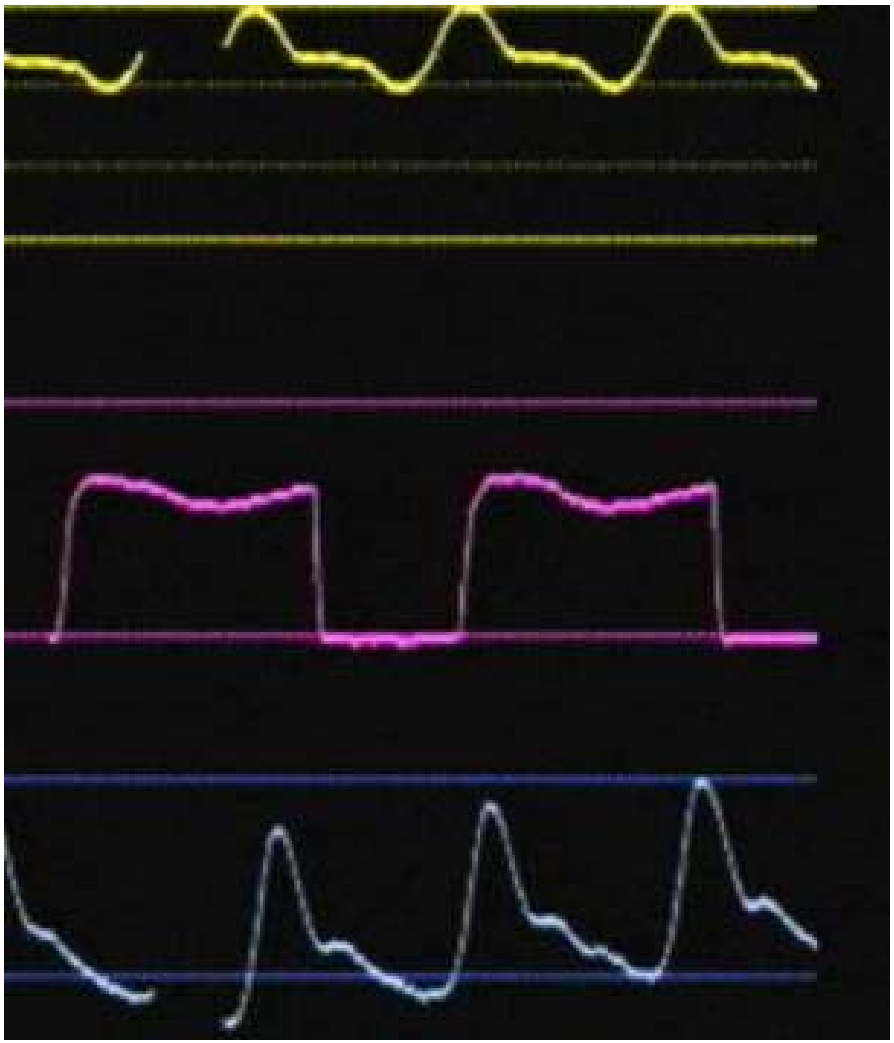
Évolution post-opératoire typique



Hypothèse unifiante?

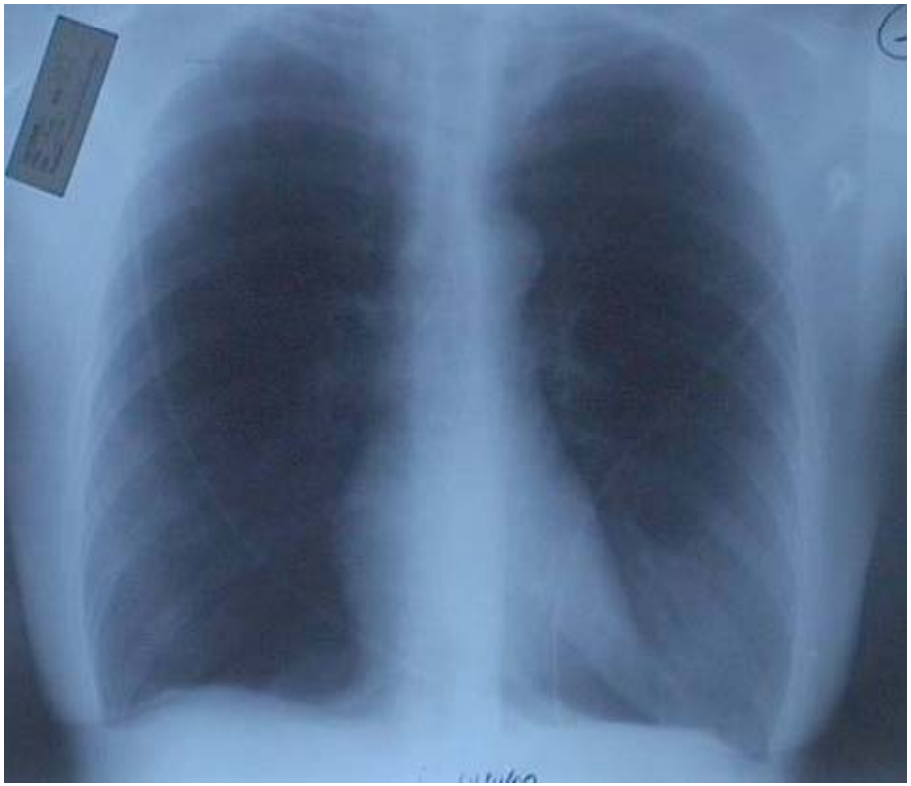
Quel type de chirurgie?

Quel type de chirurgie?



RX poumons

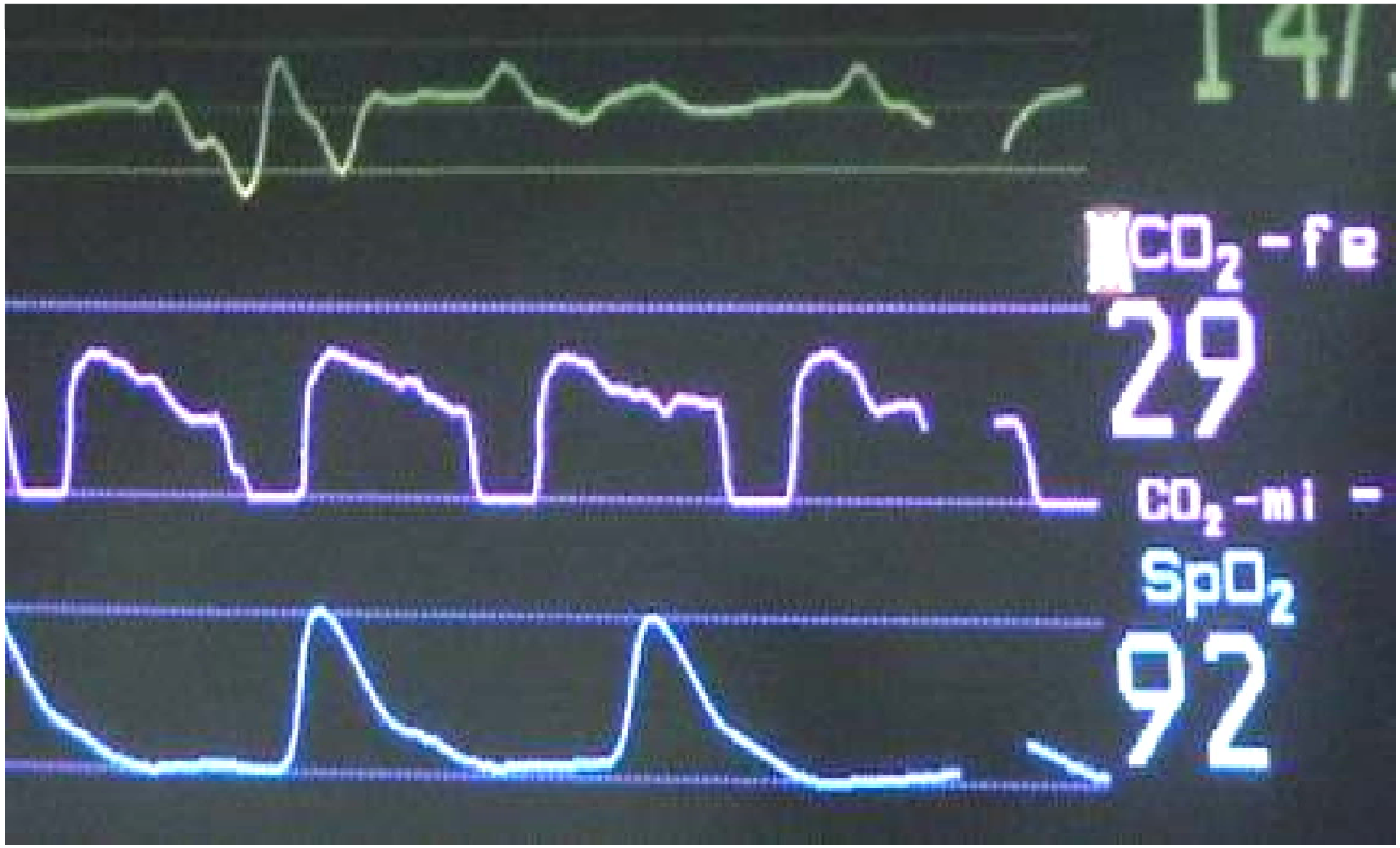
Pré-transplantation



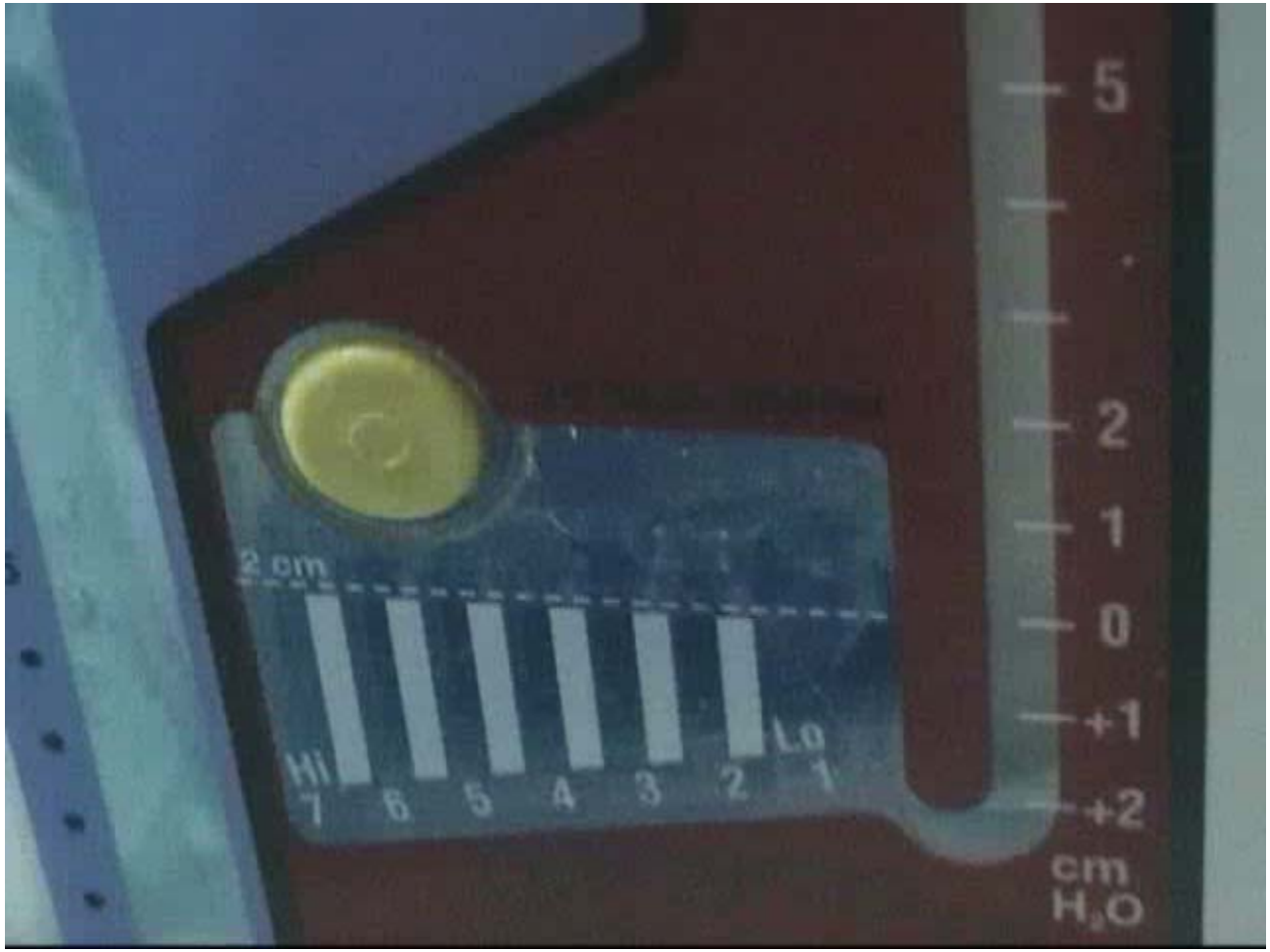
Post-transplantation

Gazométrie: pH : 7.26
PCO_2: 54
PO_2 : 166

Pourquoi avons-nous un problème de saturation?

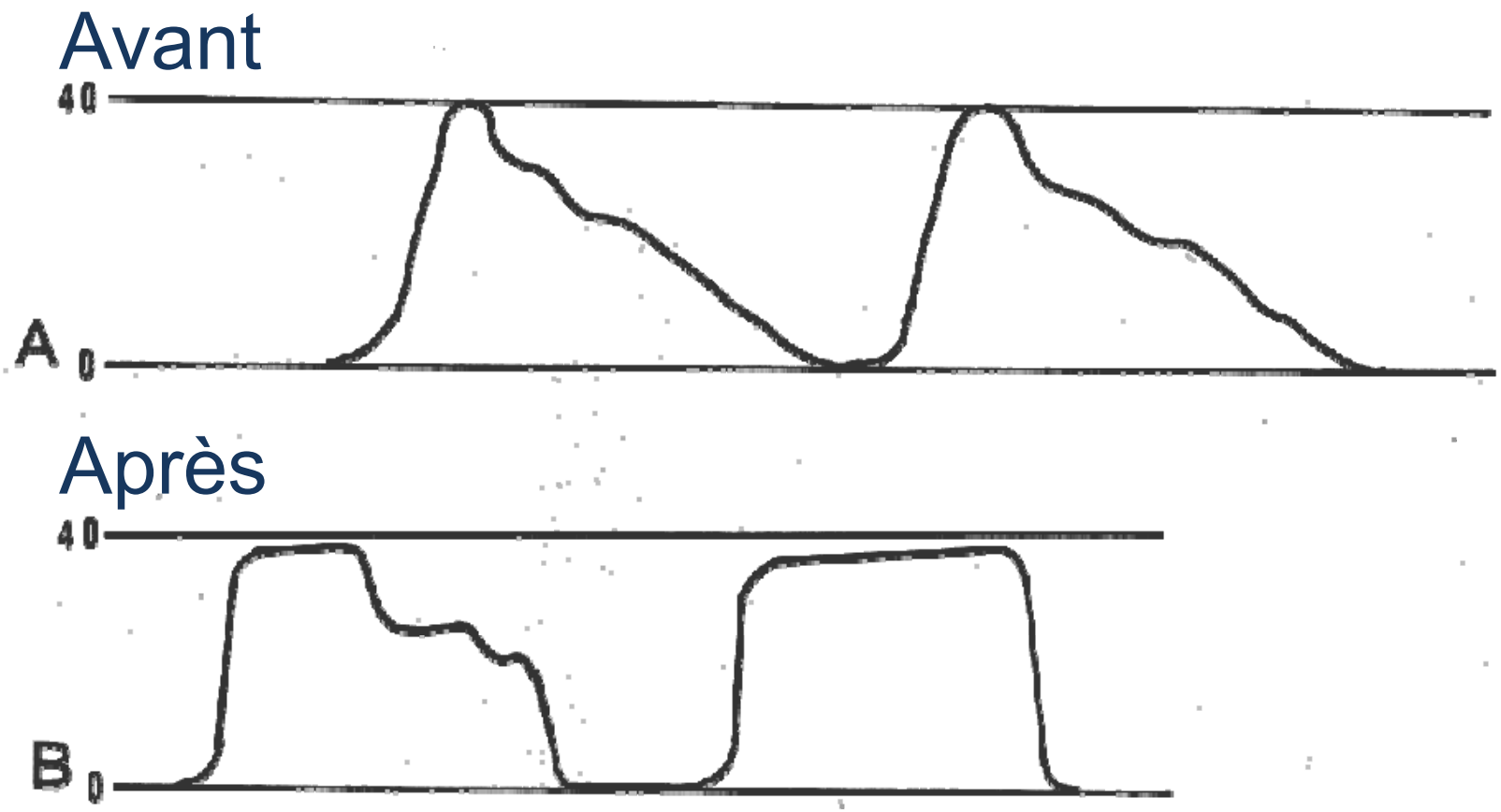

CO_2-fe
29
CO_2-mi
SpO_2
92

Pourquoi avons-nous un problème de saturation?



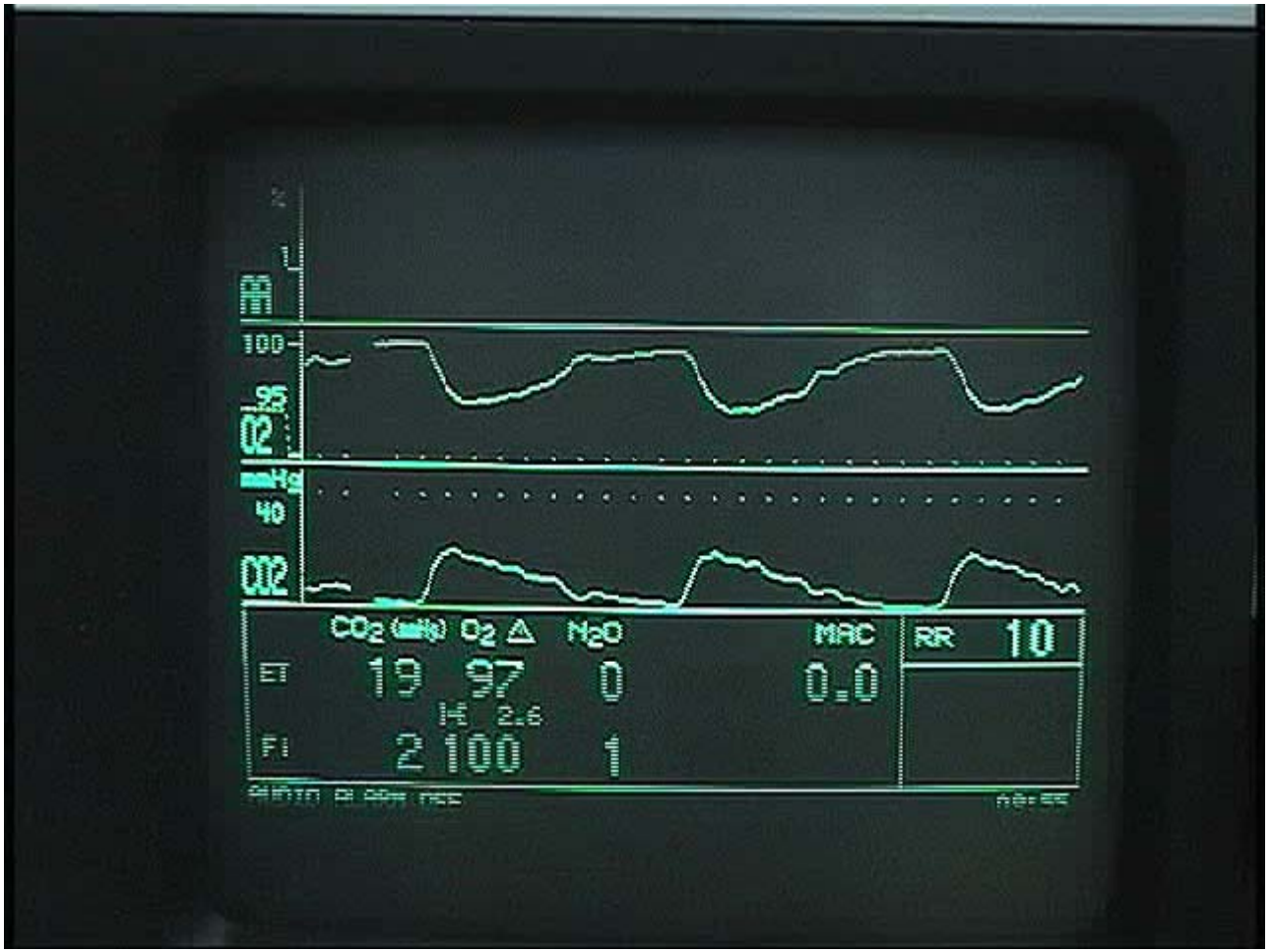
Pourquoi avons-nous un problème de saturation?

Exemple: que s ’est-il passé?

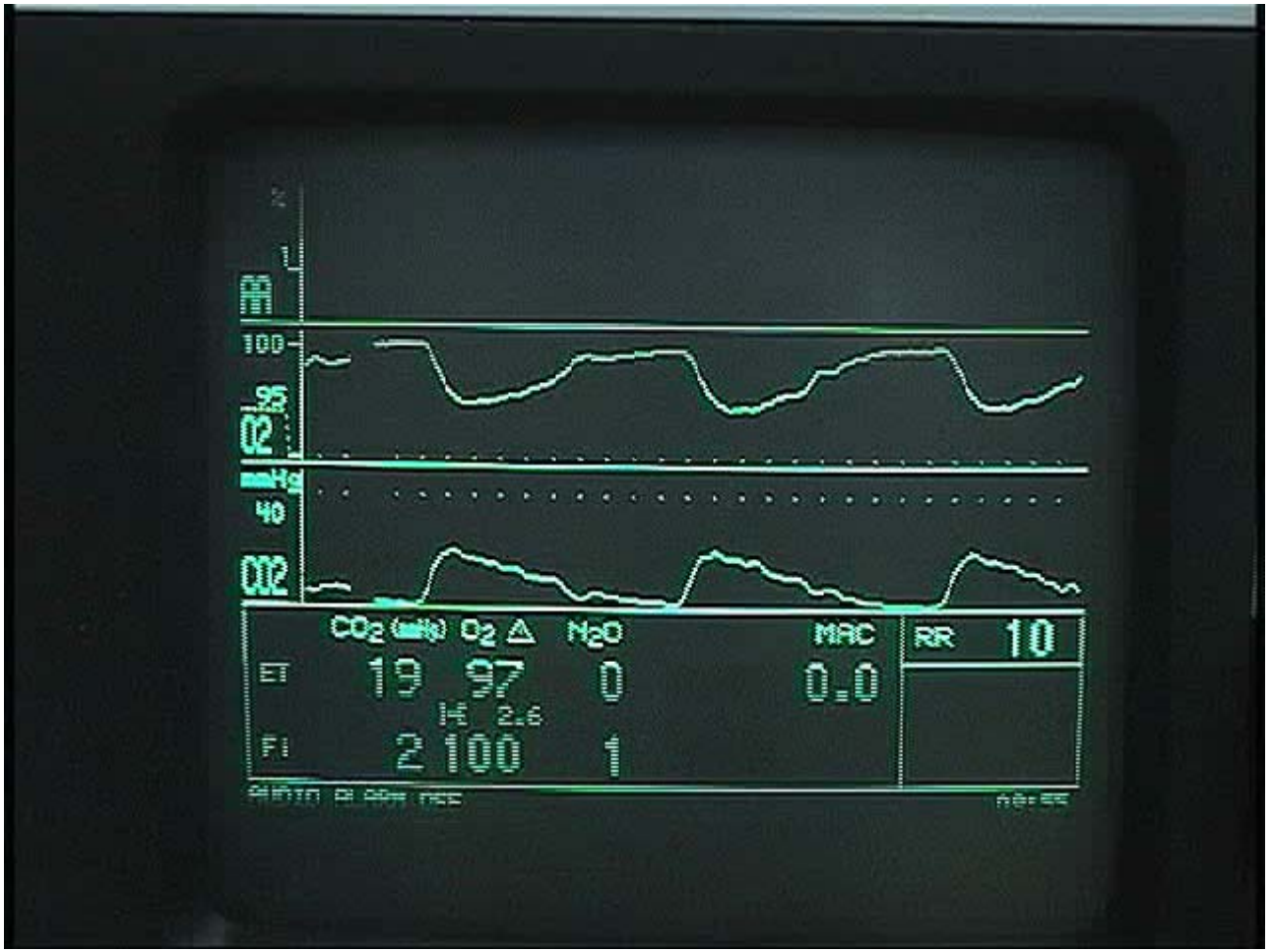


Débit d’échantillonage trop rapide

Exemple: que s’est-il passé?

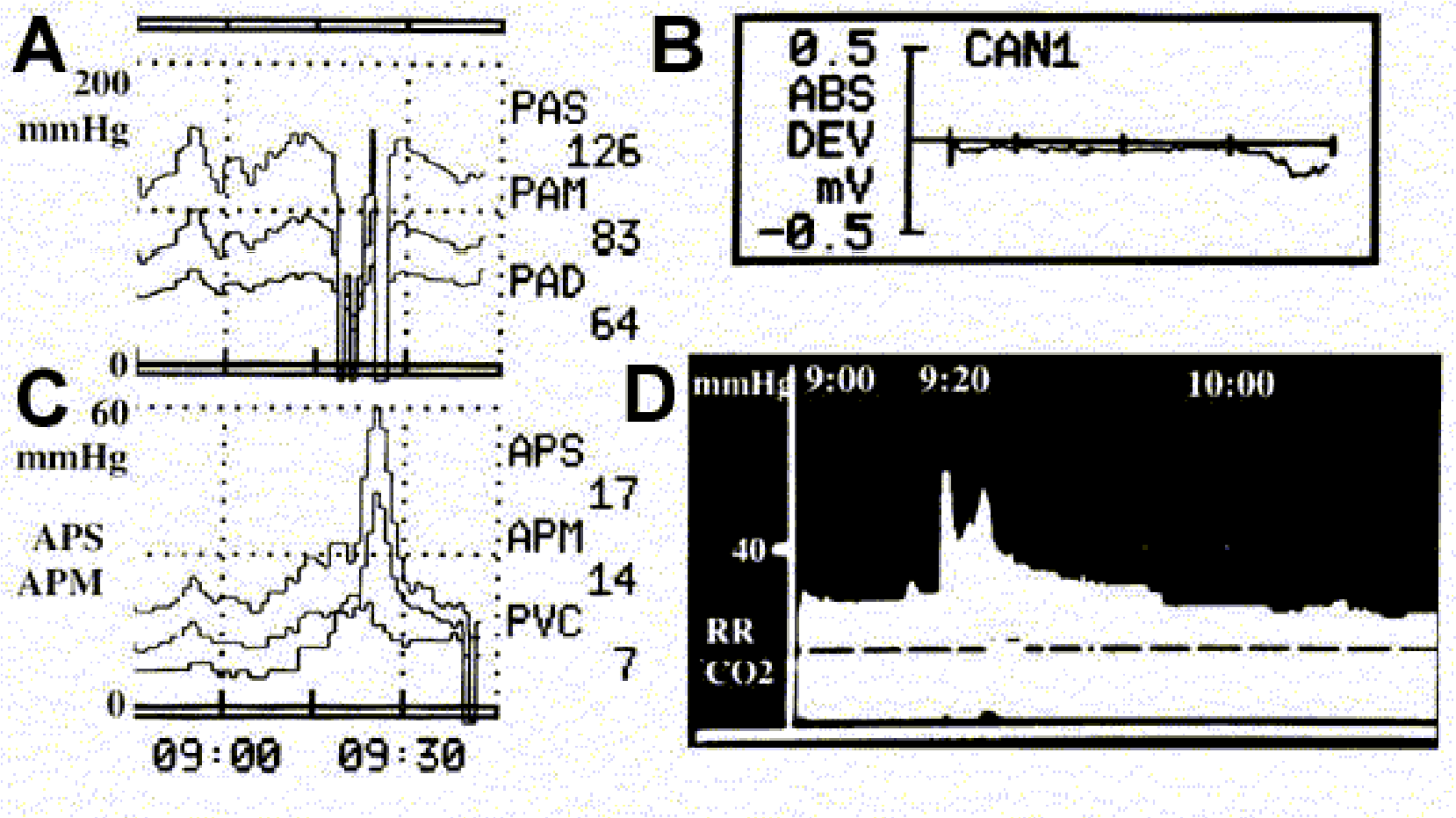


Administration de flolan par inhalation par débit secondaire



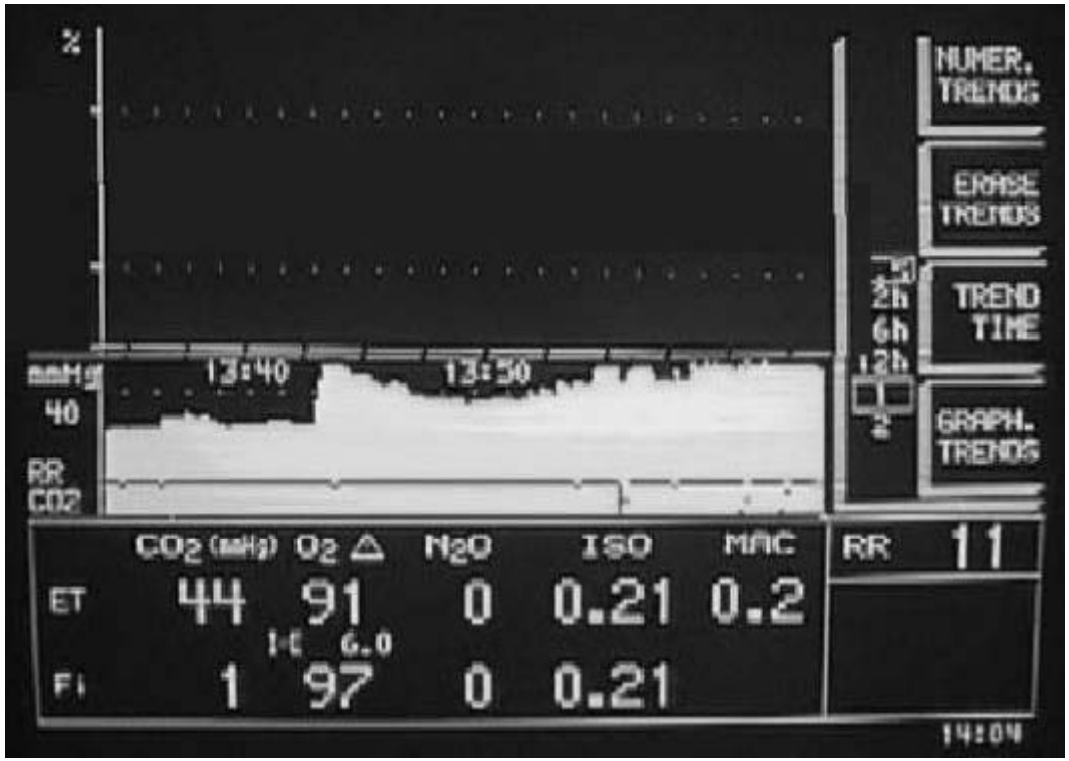
Détection de CO_2

Carbon dioxide embolism during endoscopic saphenectomy for coronary artery bypass surgery

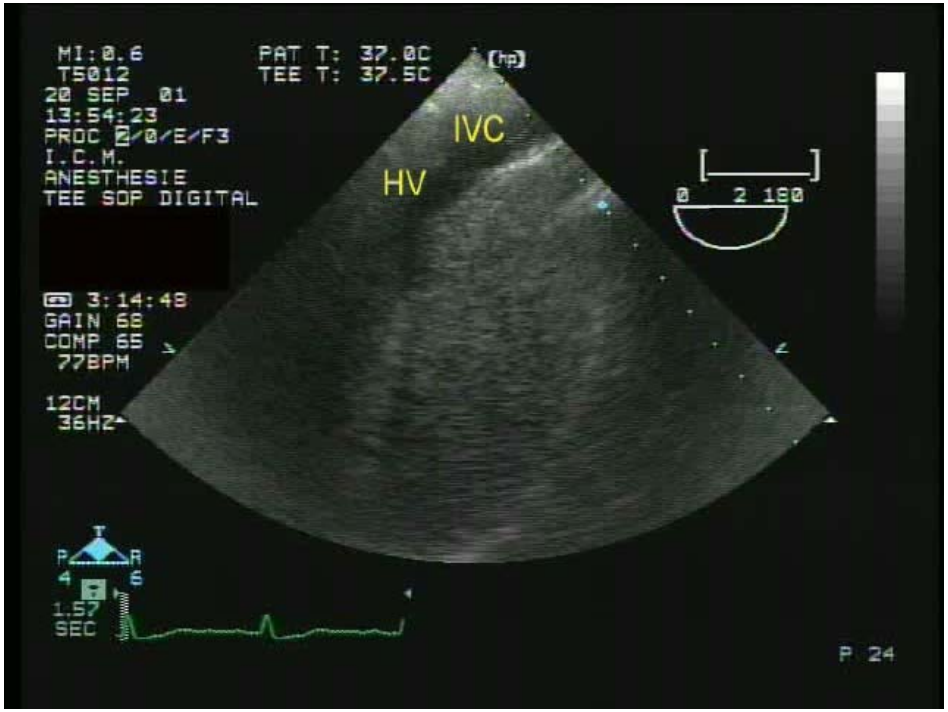


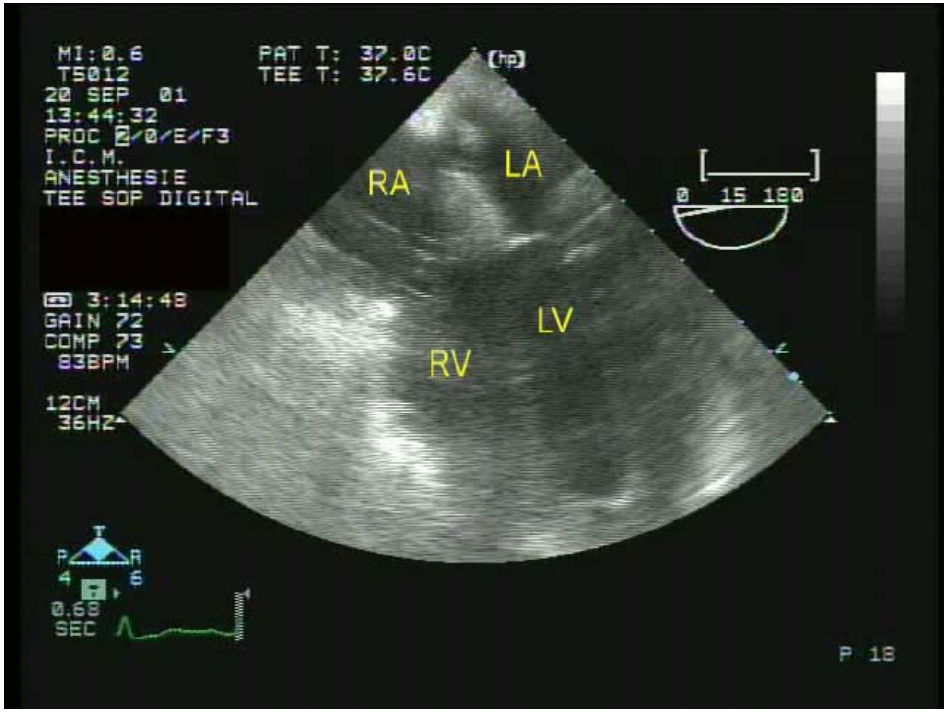
Chavanon et al. JCTVS 1999;118

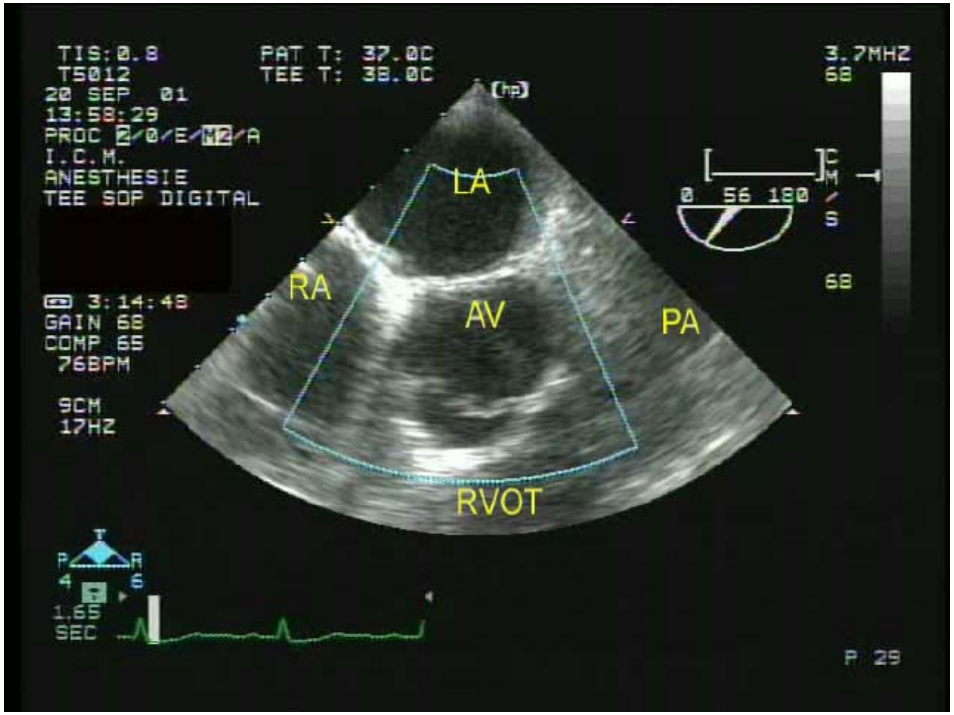
Inhaled Epoprostenol Treatment of Pulmonary Hypertension Secondary to Carbon Dioxide Embolism During Minimally Invasive Saphenous Vein Harvesting Diagnosed by Transesophageal Echocardiography

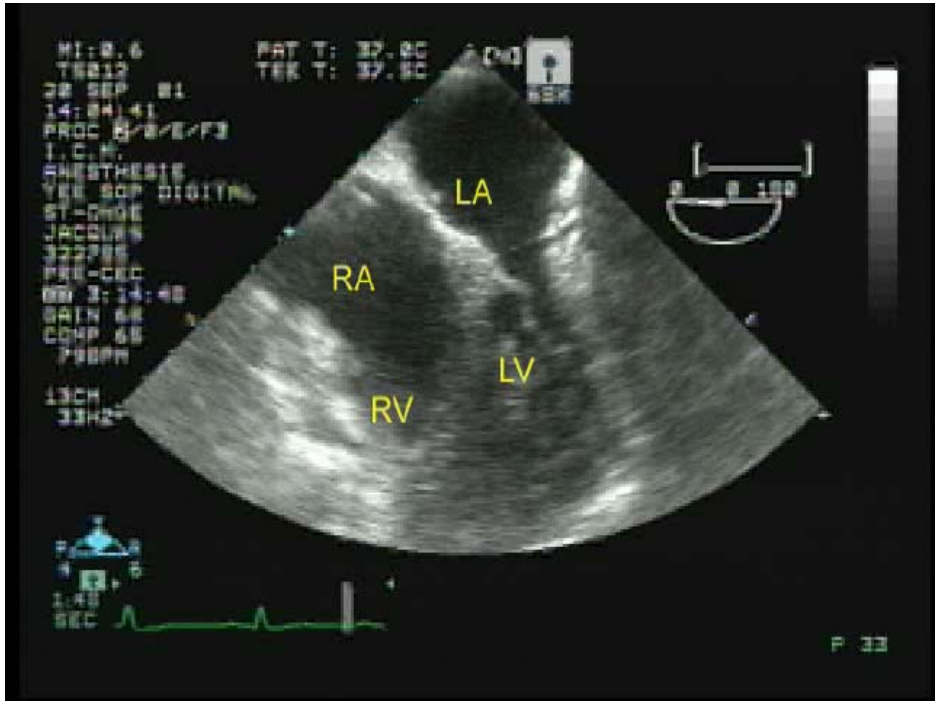


Martineau et al Anesth Anal 2001

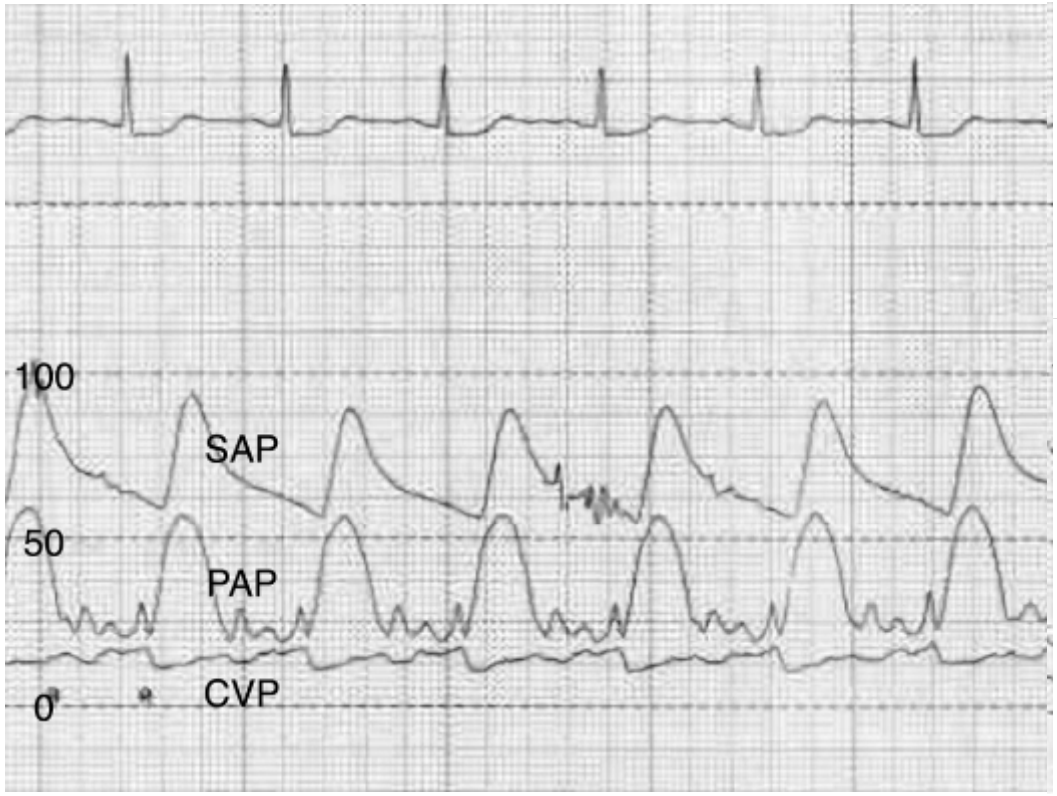

MI:0.6
T5012
20 SEP 01
13:54:23
PROC 2/0/E/F3
I.C.M.
ANESTHESIE
TEE SOP DIGITAL
PAT T: 37.0C
TEE T: 37.5C
IVC
HV
3:14:48
GAIN 68
COMP 65
77BPM
12CM
36HZ
1.57
SEC
P 24


MI:0.6
T5012
20 SEP 01
13:44:32
PROC 2/0/E/F3
I.C.M.
ANESTHESIE
TEE SOP DIGITAL
PAT T: 37.0C
TEE T: 37.6C
RA
LA
LV
RV
3:14:48
GAIN 72
COMP 73
83BPM
12CM
36HZ
0.68
SEC
P 18


TIS:0.8
T5012
20 SEP 01
13:58:29
PROC 2/0/E/M2/A
I.C.M.
ANESTHESIE
TEE SOP DIGITAL
PAT T: 37.0C
TEE T: 38.0C
3.7MHZ
68
LA
RA
AV
PA
RVOT
3:14:48
GAIN 68
COMP 65
76BPM
9CM
17HZ
1.65
SEC
P 29


LA
RA
LV
RV

Évolution post-flolan



Plan

1-Méthodes et système de mesure

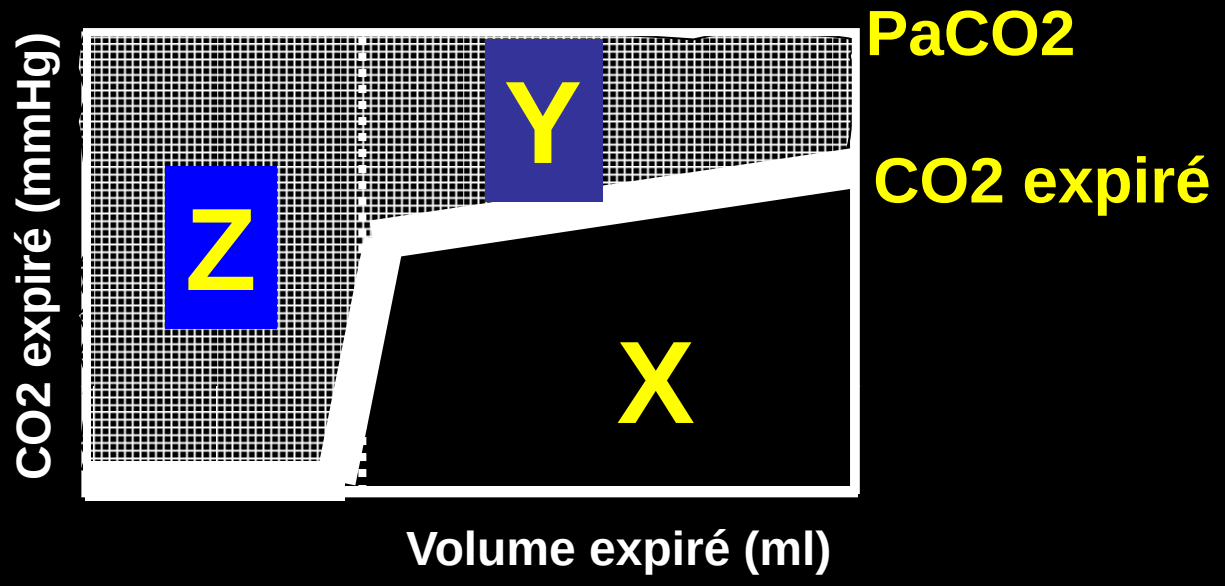
2-Physiologie du CO_2

3-Courbes de CO_2

4-CO_2 volumétrique

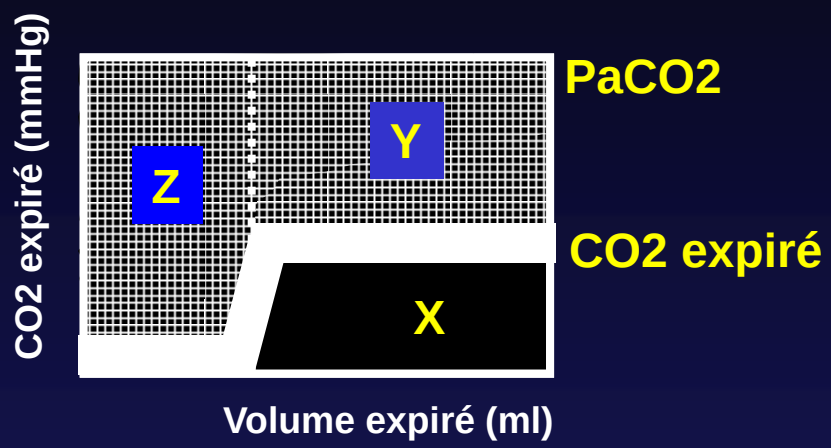
5-Autres applications

Capnographe volumétrique

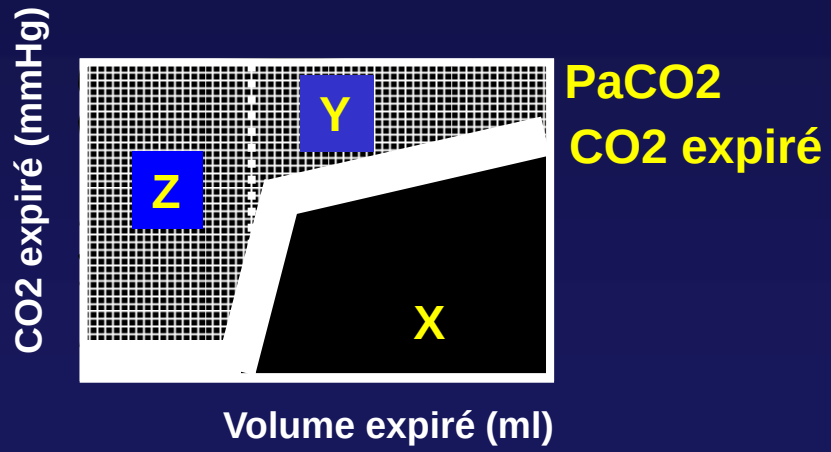


X: volume de CO_2 = ventilation efficace
Y: volume d'espace mort physiologique
Z: volume d'espace mort anatomique

Différence PaCO2 et CO2 expiré

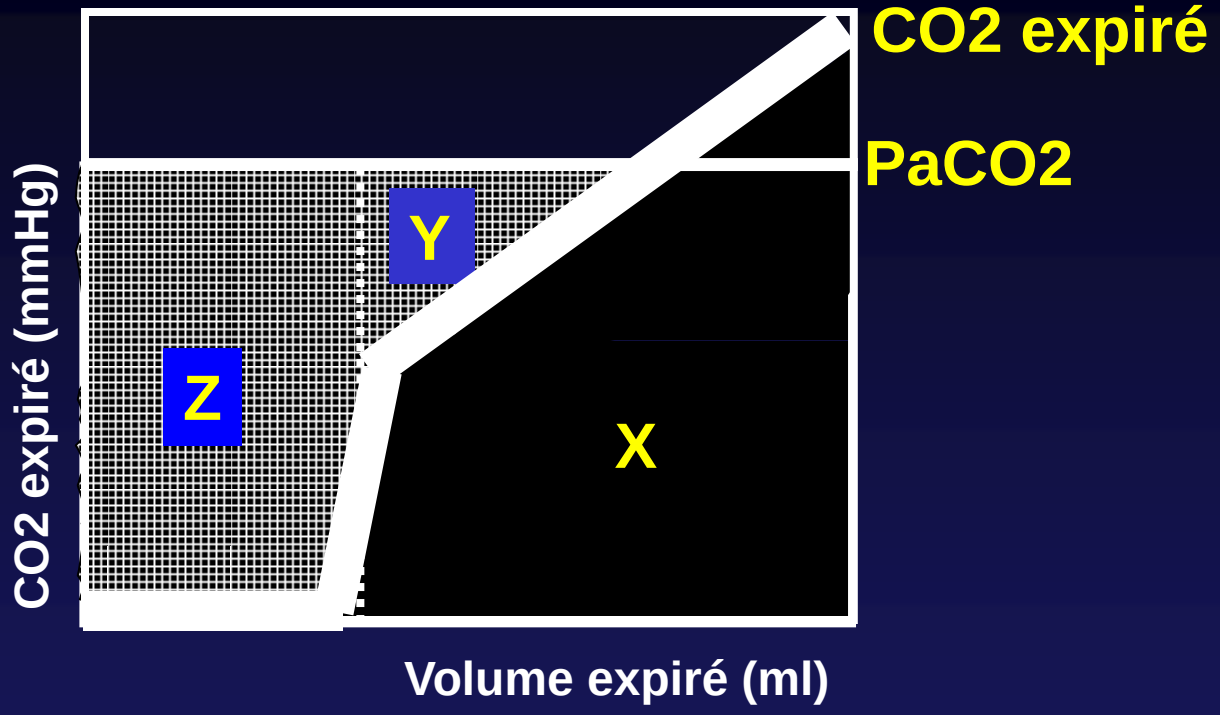


Espace mort augmenté



Espace mort diminué?

Différence $PaCO_2$ et CO_2 expiré négative



12 % des normaux (50% enfants et femmes enceintes)
Large volume courant, fréquence respiratoire lente et réduction CRF
Plus près de la $PvCO_2$

Plan

1-Méthodes et système de mesure

2-Physiologie du CO_2

3-Courbes de CO_2

4-CO_2 volumétrique

5-Autres applications

Autre applications de la capnographie

1-Ventilatoire

- ventilation spontanée et profondeur anesthésie
- ajustement du débit de gaz frais
- guider l'intubation à l'aveugle
- ajustement du PEEP et recrutement alvéolaire
- tube double lumière
- ventilation par jet
- sevrage du ventilateur

2-Circulatoire

- moniteur de débit cardiaque
- sevrage de CEC
- détection d'embolie pulmonaire et gazeuse
- réanimation

3-Autre: états hypermétaboliques: « FET »

A REVIEW OF PEDIATRIC CAPNOGRAPHY

Naveen Eipe, MBBS, MD[1,2] *and Dermot R. Doherty, MB, BCh, BAO, FCARCSI, EDIC*[3]

The search methods identified eight hundred and 21 (875) citations. From these, 44 different clinical applications or interpretations of capnography in children were listed.

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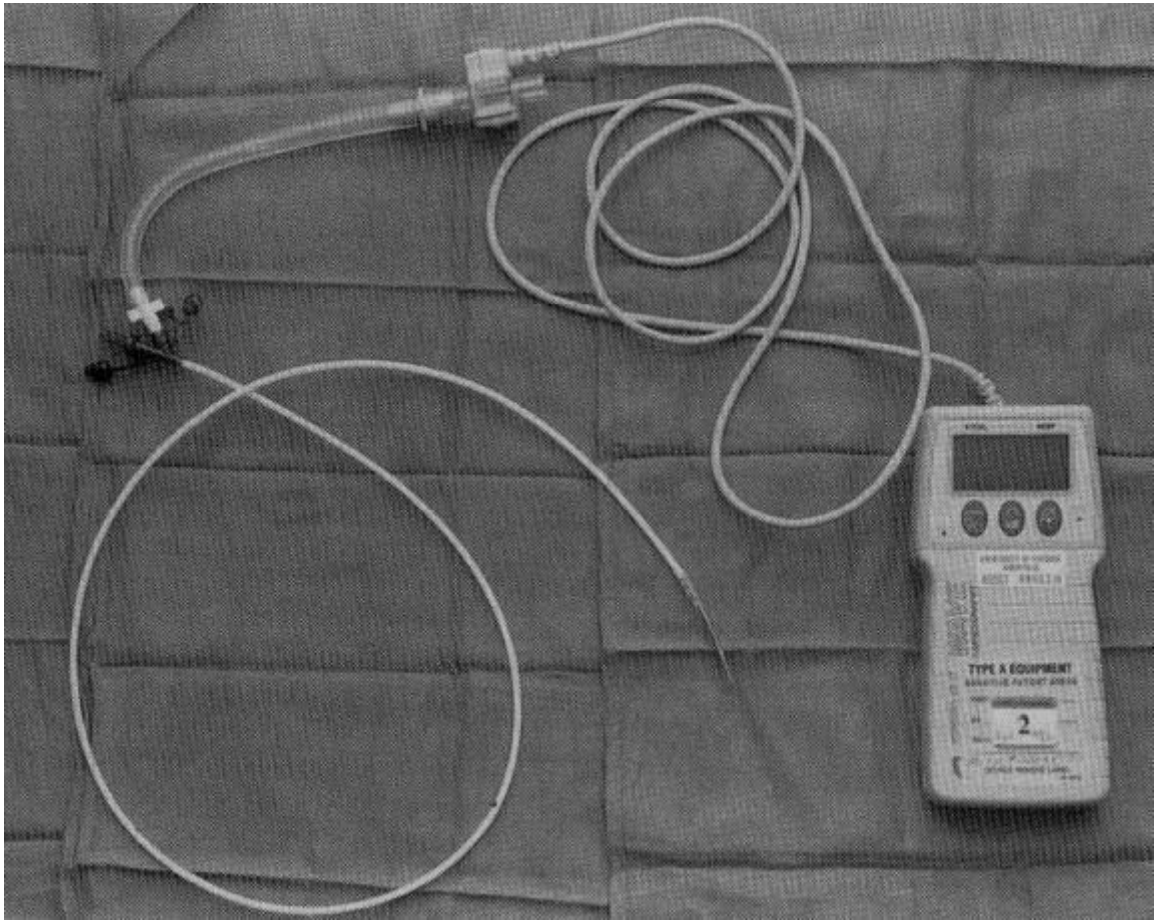
Table 1. Applications and interpretations of capnography in children

Category [4]	Application	Example of reference	Grade of recommendation [CEBM] [5]
Anesthetic delivery	it disconnections/adequate gas delivery	[6]	B
	al—end tidal relationship	[7]	B
	sedation—detecting airway and respiratory events	[9]	B
Airway	Analysis of rebreathing circuits/adequate fresh gas flow	[10]	C
	Detect exhausted soda lime	[11]	D
	One way valve function	[12]	C
	Sampling line disconnection	[13]	D
	Patency of natural airway	[14]	A
	Confirms tracheal intubation/rules out esophageal intubation	[15]	A
	Measure of arterial CO_2 during spontaneous breathing through a LMA	[16]	C
	Detect leak and determine size of un-cuffed tracheal tubes	[18]	C
	During difficult airway maneuvers	[19]	D
	Bronchoscopy	[21]	C
Breathing	Single-lung ventilation	[22]	D
	Adequacy of spontaneous ventilation	[23]	C
	Adequacy of mechanical ventilation	[24]	B
	Onset, waning or reversal of neuromuscular blockade	[6]	C
	Dead space calculation	[25]	D
	Severity and treatment of asthma	[26]	B
	Trans tracheal jet ventilation	[28]	C
	Heliox therapy	[29]	C
Circulation	Estimating cardiac output	[31]	C
	Pulmonary embolism	[32]	C
	Congenital heart disease	[34]	C
	During cardiac surgery	[37]	C
	Cardiac arrhythmias	[38]	C
	Cardiac oscillations	[39]	D
Homeostasis	Overall metabolic state	[40]	B
	Sepsis, fever and malignant hyperthermia	[41]	B
	Laparoscopic surgery	[42]	D
	Respiratory failure	[43]	C
	Metabolic acidosis	[44]	B
	Cerebral effects	[45]	C
	l/inotropic support	[46]	C
Non-Perioperative	pital intubation	[47]	D
	monitor	[48]	B
	ROSC/CPR	[51]	C
	Sleep studies	[52]	C
	Seizure studies	[54]	C
	Monitoring for SIDS	[55]	D
	Neonatal lung testing	[56]	D
	Analysis of lung growth	[57]	C
	Enteral tube placement	[58]	B
	Assessment of transcutaneous capnometry	[59]	B

CEBM grades of recommendation. *A* consistent level 1 studies. *B* consistent level 2 or 3 studies or extrapolations from level 1 studies. *C* level 4 studies or extrapolations from level 2 or 3 studies. *D* level 5 evidence or troublingly inconsistent or inconclusive studies of any level

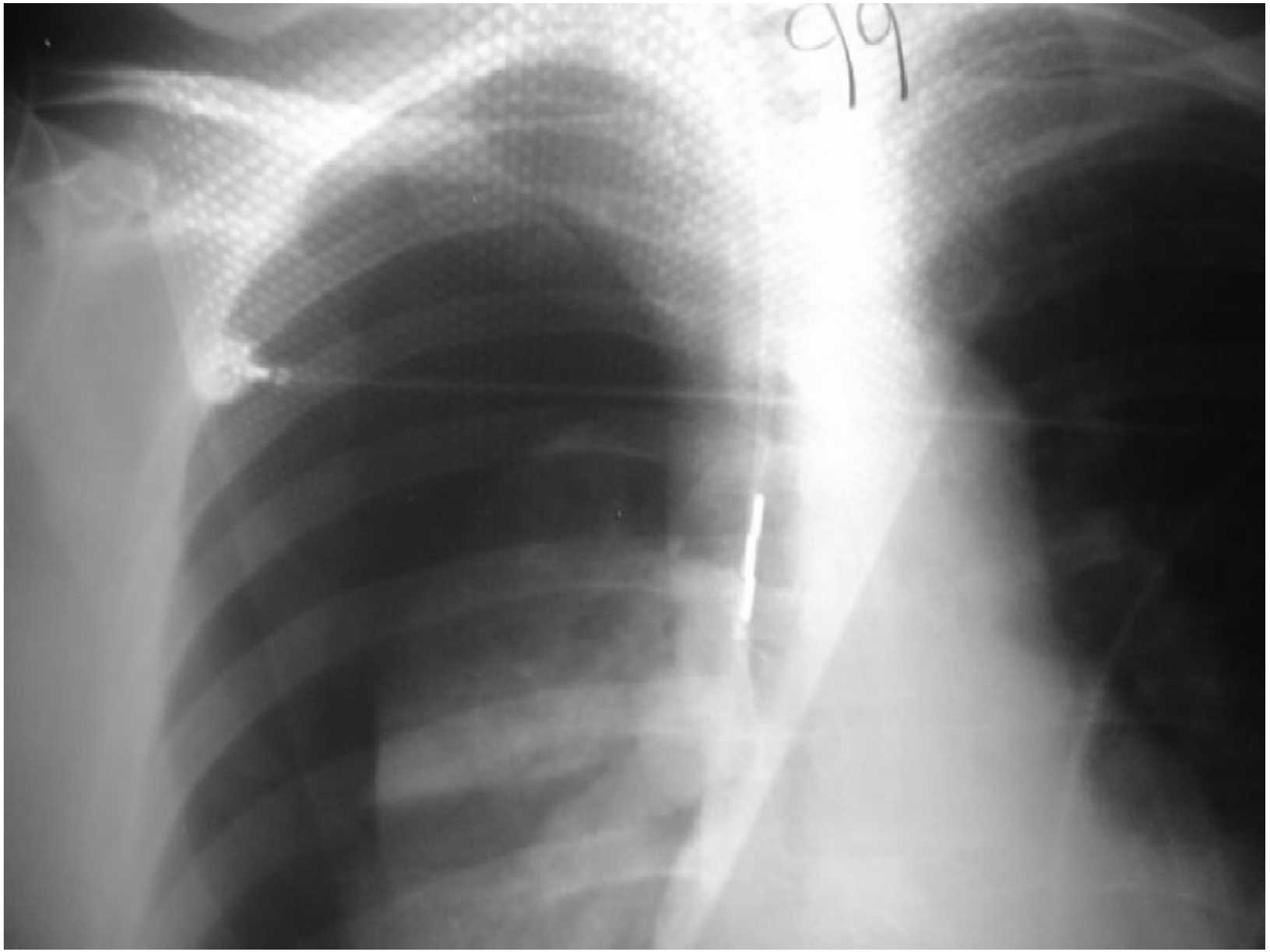
Positionnement du duotube



Sensibilité et spécificité 100%

Burns SM et al Crit Care Med 2001:29;936-939

Duotube pulmonaire



Autre application: ♂ 70 ans redo plastie mitrale et CIA: fin du cas

23 Février 2005

♂ 70 ans redo plastie mitrale et CIA

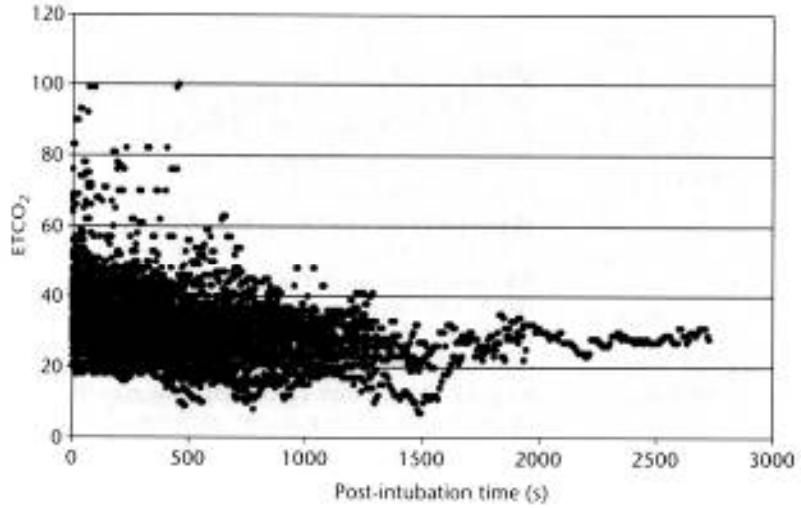
Valeur pronostique de la capnographie

- Trauma
- ARDS
- Réanimation

Mortalité et hyperventilation

Aucune indication d'hyperventilation sauf hernie intra-cérébrale imminente ($PaCO_2$ 40-45 mmHg)

50% des intubation avec $ETCO_2$ < 25 mmHg (Davies et al 2004 Neu. Crit Care)



Hyperventilation préviens réanimation dans les arrêt cardiaque. (Aufderheide et al. Circulation 2004;1960)

« Unrecognized and inadvertent hyperventilation may be contributing to the currently dismal survival rates from cardiac arrest »

ARDS et espace-mort

PULMONARY DEAD-SPACE FRACTION AS A RISK FACTOR FOR DEATH IN THE ACUTE RESPIRATORY DISTRESS SYNDROME

THOMAS J. NUCKTON, M.D., JAMES A. ALONSO, R.R.T., RICHARD H. KALLET, R.R.T., M.S., BRIAN M. DANIEL, R.R.T., JEAN-FRANÇOIS PITTET, M.D., MARK D. EISNER, M.D., M.P.H., AND MICHAEL A. MATTHAY, M.D.

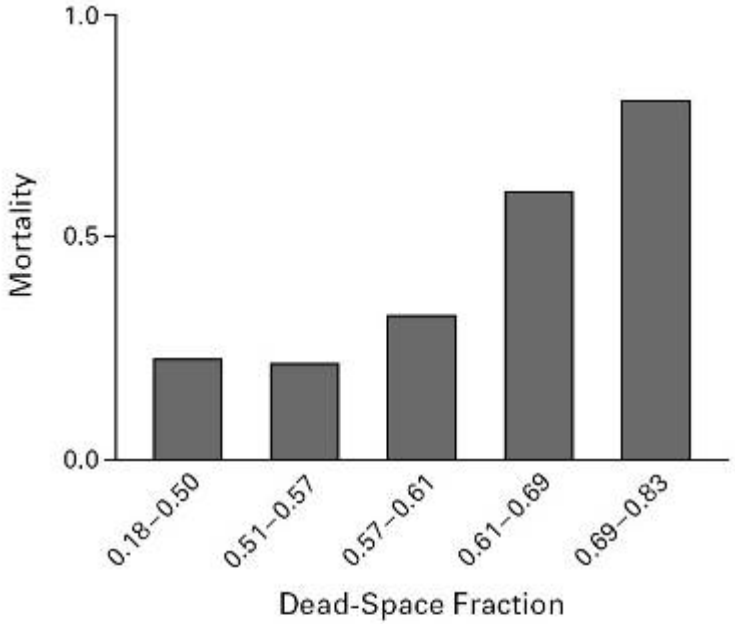
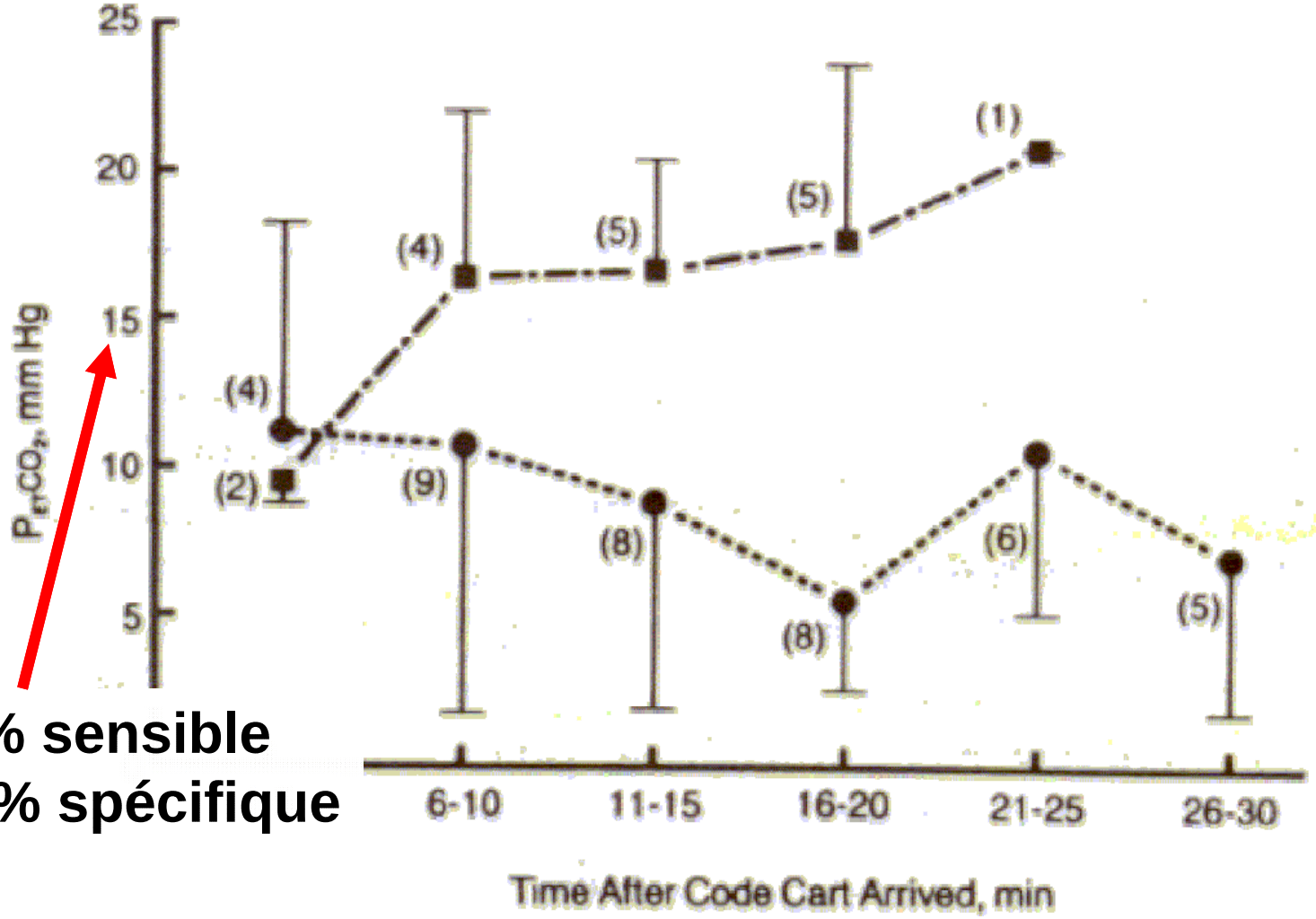


Figure 1. The Observed Mortality According to the Quintile of Dead-Space Fraction in 179 Patients with the Acute Respiratory Distress Syndrome.

« Elevated value are associated with an increase risk of death »

NEJM 2002;346:1281-6

Capnographie et réanimation



71% sensible
98% spécifique

Falk JL Adv Anesthesia 1993:10

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Previous Volume 337:301-306 July 31, 1997 Number 5 Next ▸

End-Tidal Carbon Dioxide and Outcome of Out-of-Hospital Cardiac Arrest

Robert L. Levine, M.D., Marvin A. Wayne, M.D., and Charles C. Miller, Ph.D.

1-After 20 minutes of advanced cardiac life support, end-tidal carbon dioxide (±SD) averaged 4.4±2.9 mm Hg in nonsurvivors and 32.8±7.4 mm Hg in survivors ($P < 0.001$).

Limitations de la capnographie

1-Calibration et vérification

2-TET dans le pharynx (œil de Murphy)

3-Si intubation difficile: air riche en CO_2 dans l'estomac (sphincter GE incompétent) et si TET esophagien $ETCO_2$ positif initialement

4-Hypoventilation: débit expiratoire < debit d 'aspiration

5-Choisir le type de capnographe ou capnomètre

6-Mal interpréter le CO_2 expiré

7-Si TET endobronchique: $ETCO_2$ normal (15%), diminue (6%) et augmente (5%)

8-Tachypnée: cycle respiratoire > temps de réponse du capnographe (problème si > 30/min)

Capnographic Waveforms in the Mechanically Ventilated Patient

John E Thompson RRT FAARC and Michael B Jaffe PhD

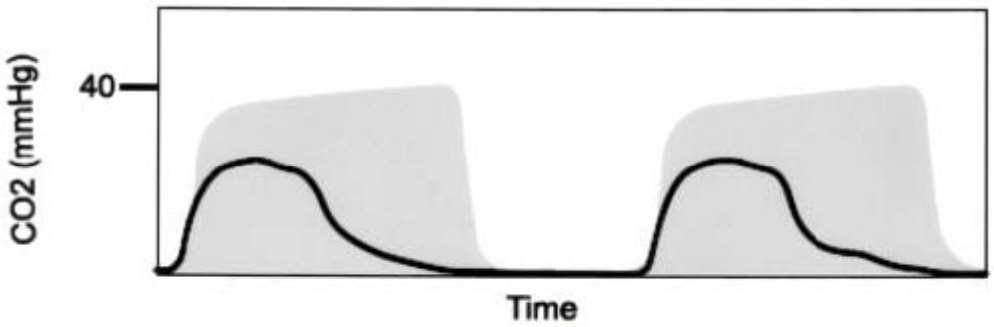
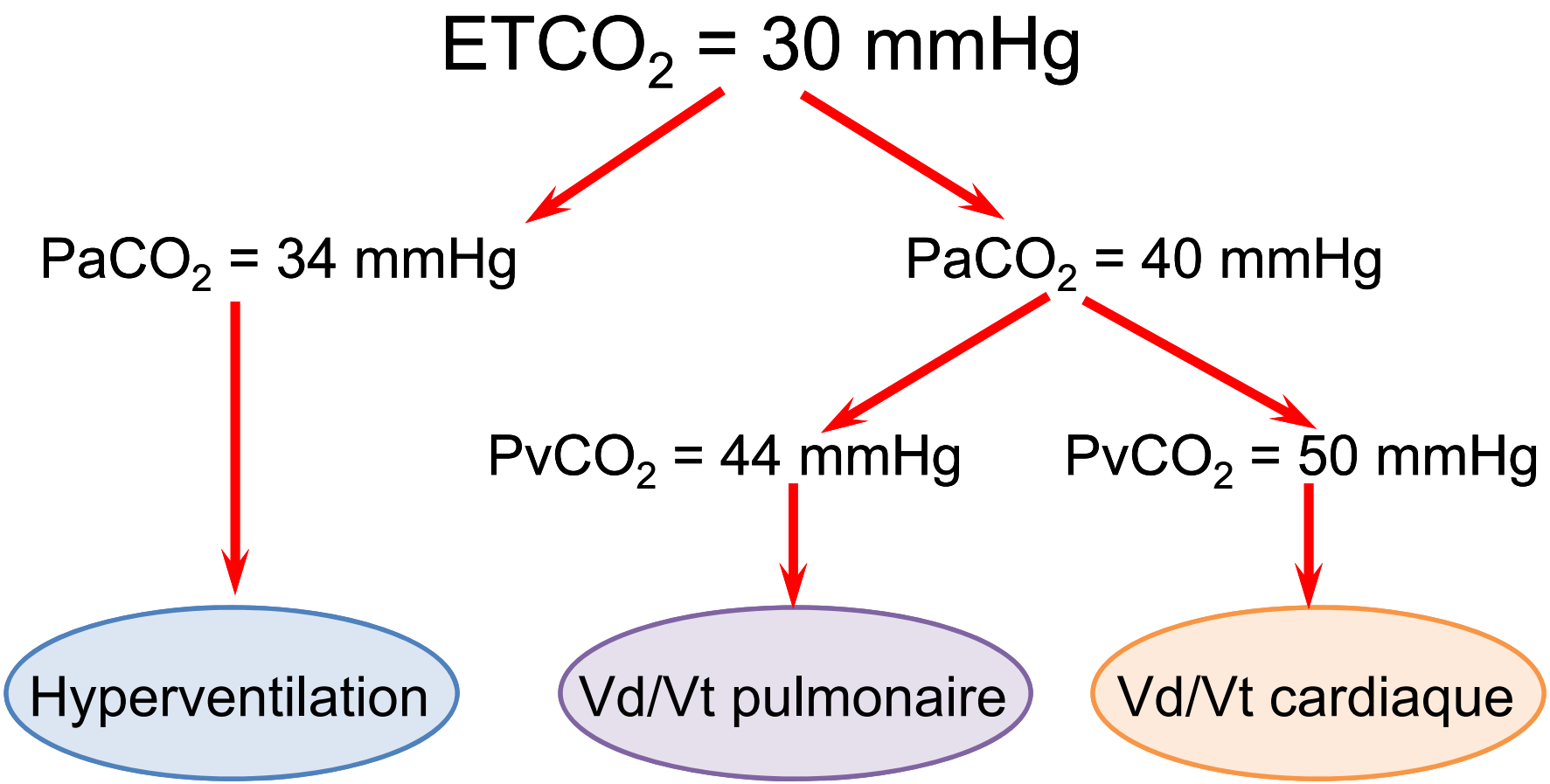


Fig. 8. Acute change in capnogram from normal (shaded area). The endotracheal tube was in the right main bronchus.

capnogram (Fig. 8). For example, the procedure of turning and flexing a patient to position him for a spinal tap resulted in a right main-bronchus migration of the ETT that was first indicated by a change in the capnogram. This

Capnographie et gradient AV PCO_2



Can J Anesth/J Can Anesth (2011) 58:1–7
DOI 10.1007/s12630-010-9411-4

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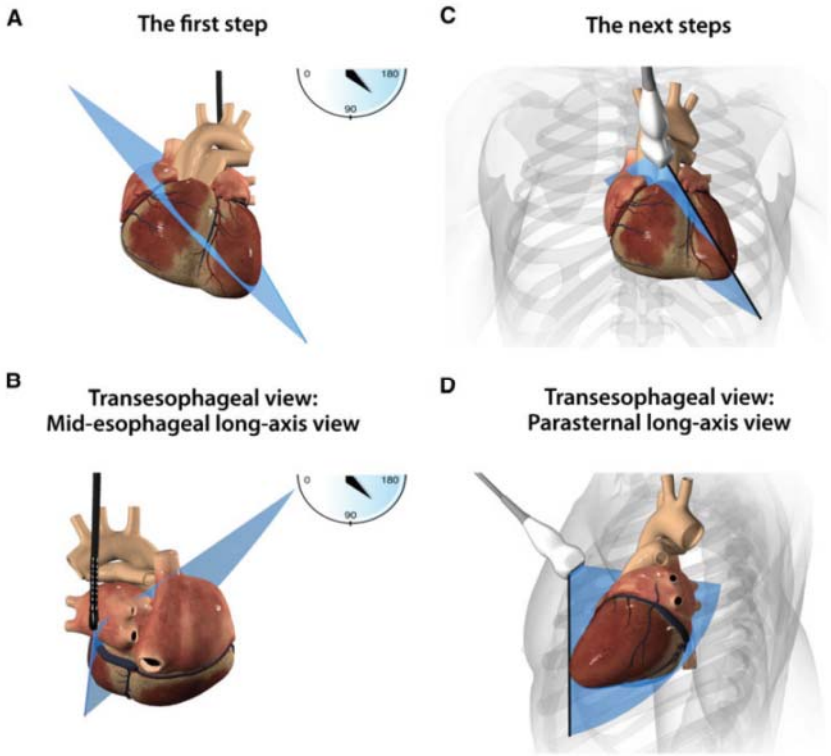
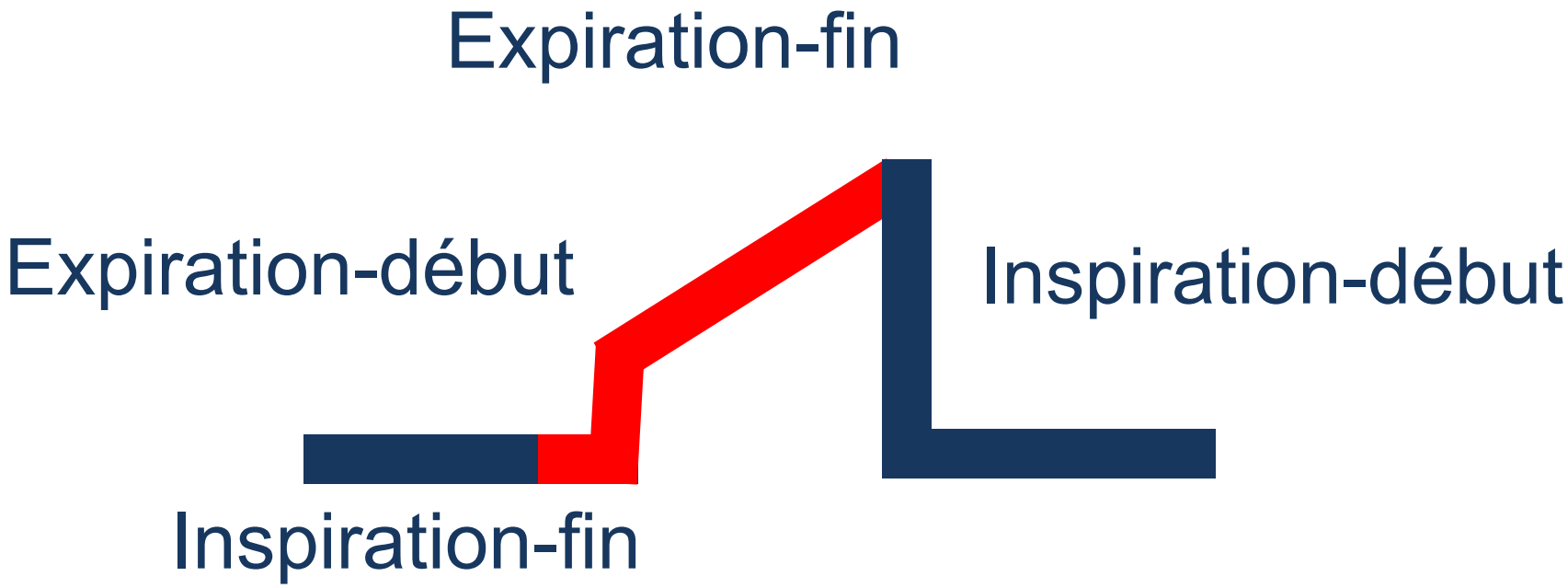
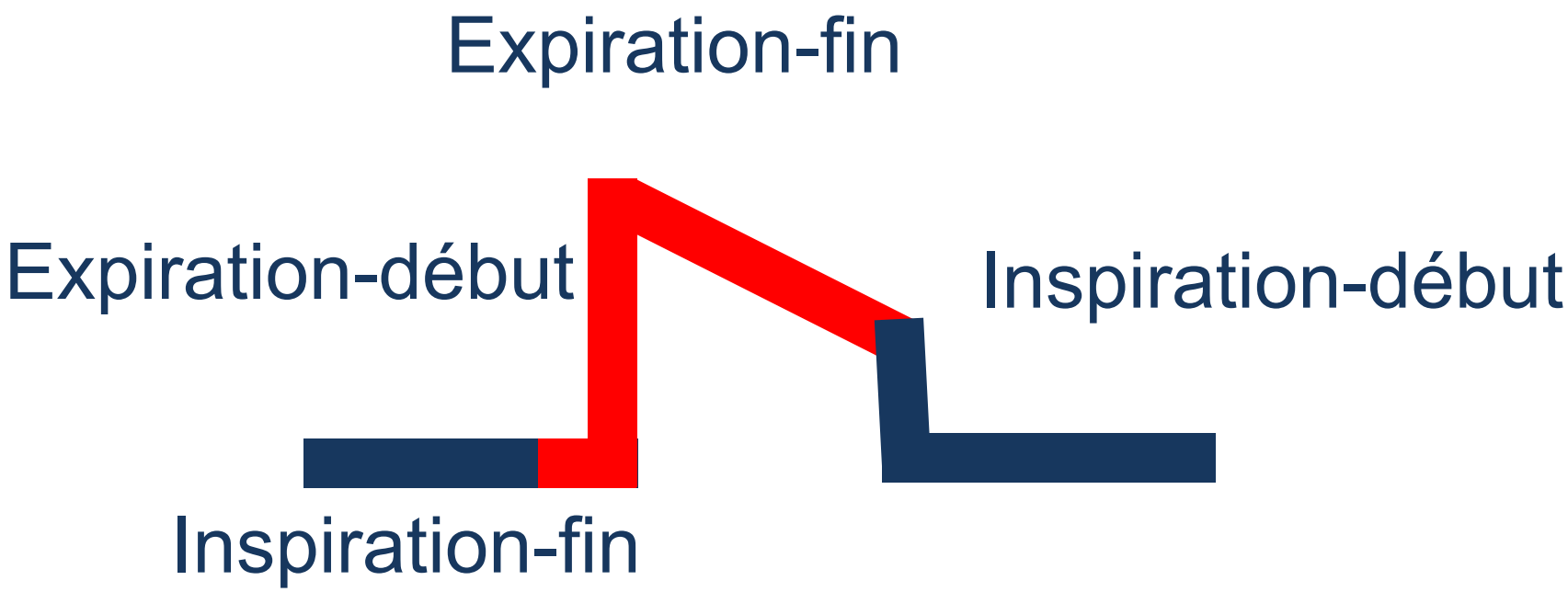


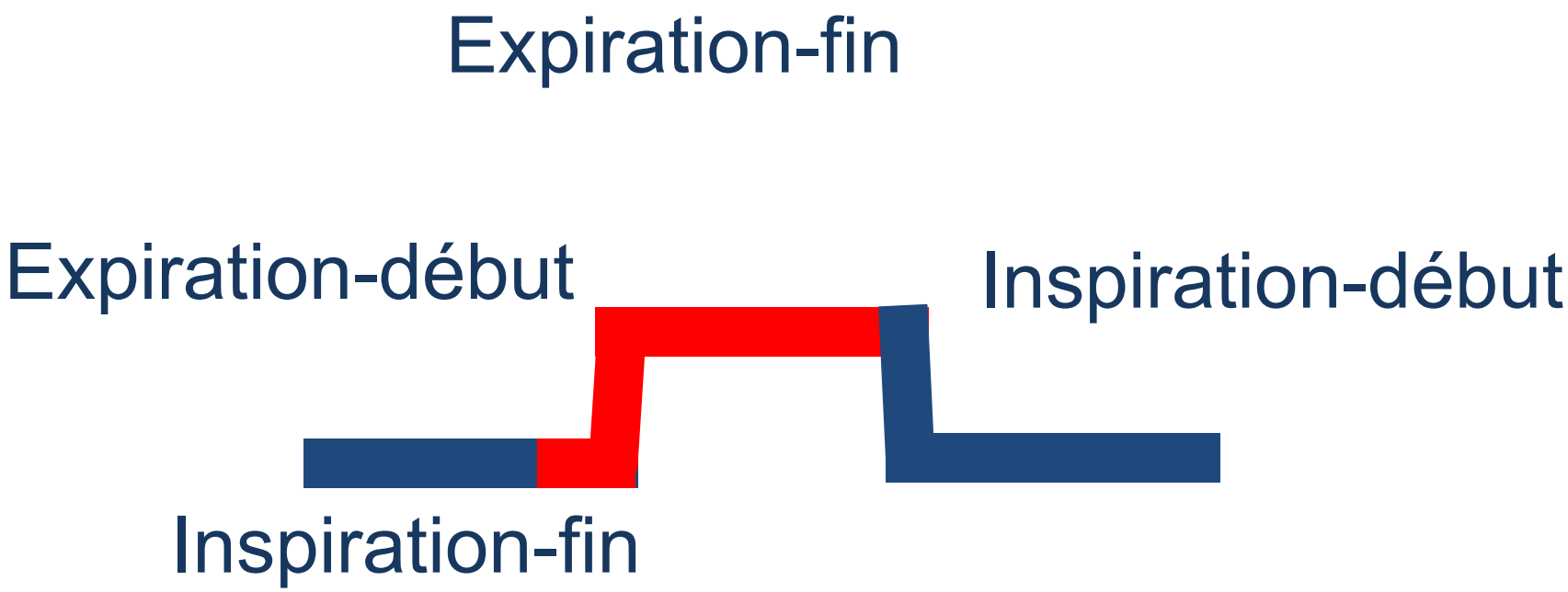
Tracé capnographique I Bronchospasme



Tracé capnographique II: fuite de gaz expiré ou source externe



Tracé capnographique III: baisse de débit cardiaque



Résumé: Rôle de la capnographie

A: « Airway » ou détecteur du le positionnement du TET

B: « Breathing » ou détecte la présence d'une ventilation, sa fréquence, le type de ventilation, les anomalies V/Q, estime la $PaCO_2$ et la profondeur de l'anesthésie ou de la sédation

C: Circulation sanguine pulmonaire et systémique: moniteur de débit cardiaque et des interventions hémodynamiques

D: Diagnostique: MPOC, le CO_2 dans le circuit d'anesthésie (intrinsèque ou extrinsèque), fuite du ballonet, fistule broncho-pleurale, extubation imminente, duotube pulmonaire

E: Espérance de survie dans l'ARDS et arrêt cardiaque


COMPAQ
Bell

Denis Babin
MSc Inh

Remerciements