

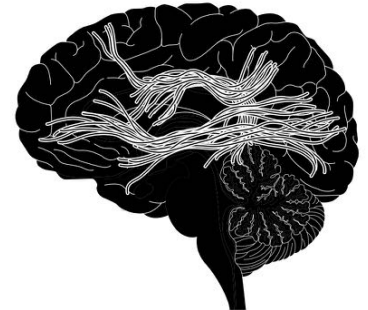


#23 Edition 2.3.4 Juin 2021

# Protection cérébrale après arrêt cardiaque



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I.D.E, Médecine Intensive Réanimation  
Hôpital Cochin, Assistance Publique-Hôpitaux de Paris



# DÉCLARATION DE LIENS

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- BARD



# LE CHALLENGE N'EST PAS QUE PRÉ-HOSPITALIER

40.000 ACR/an



60% RCP

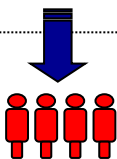


15-20% RACS...



Période pré-hospitalière

... et d'admissions en réa



8-9% survivants



7% CPC1-2



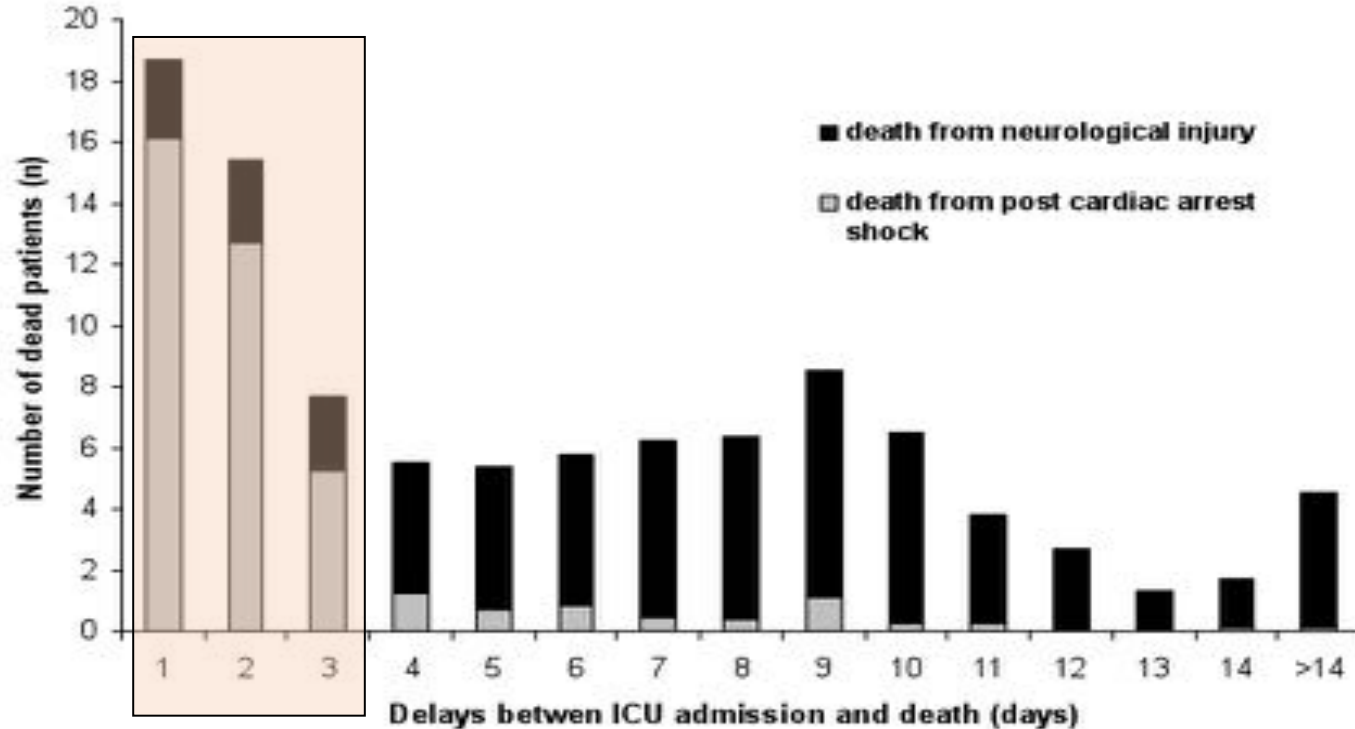
Long terme



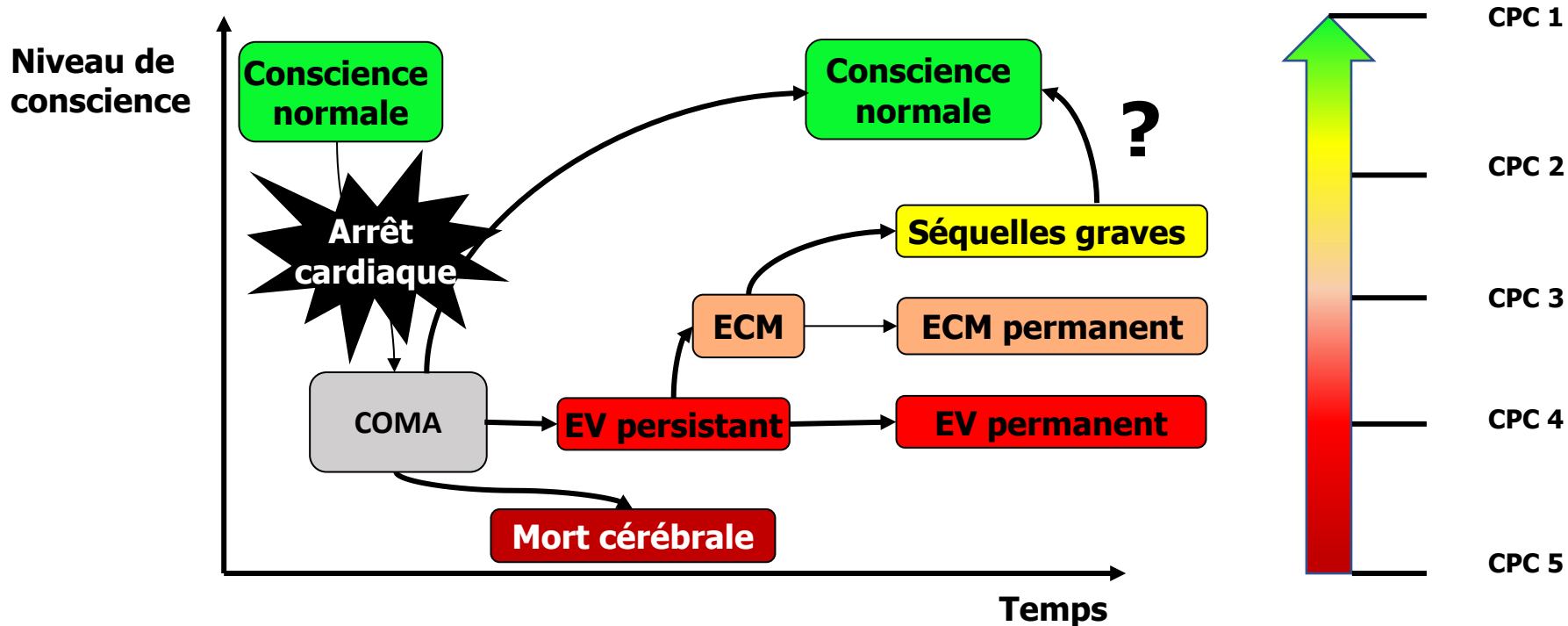
Post-arrêt cardiaque :

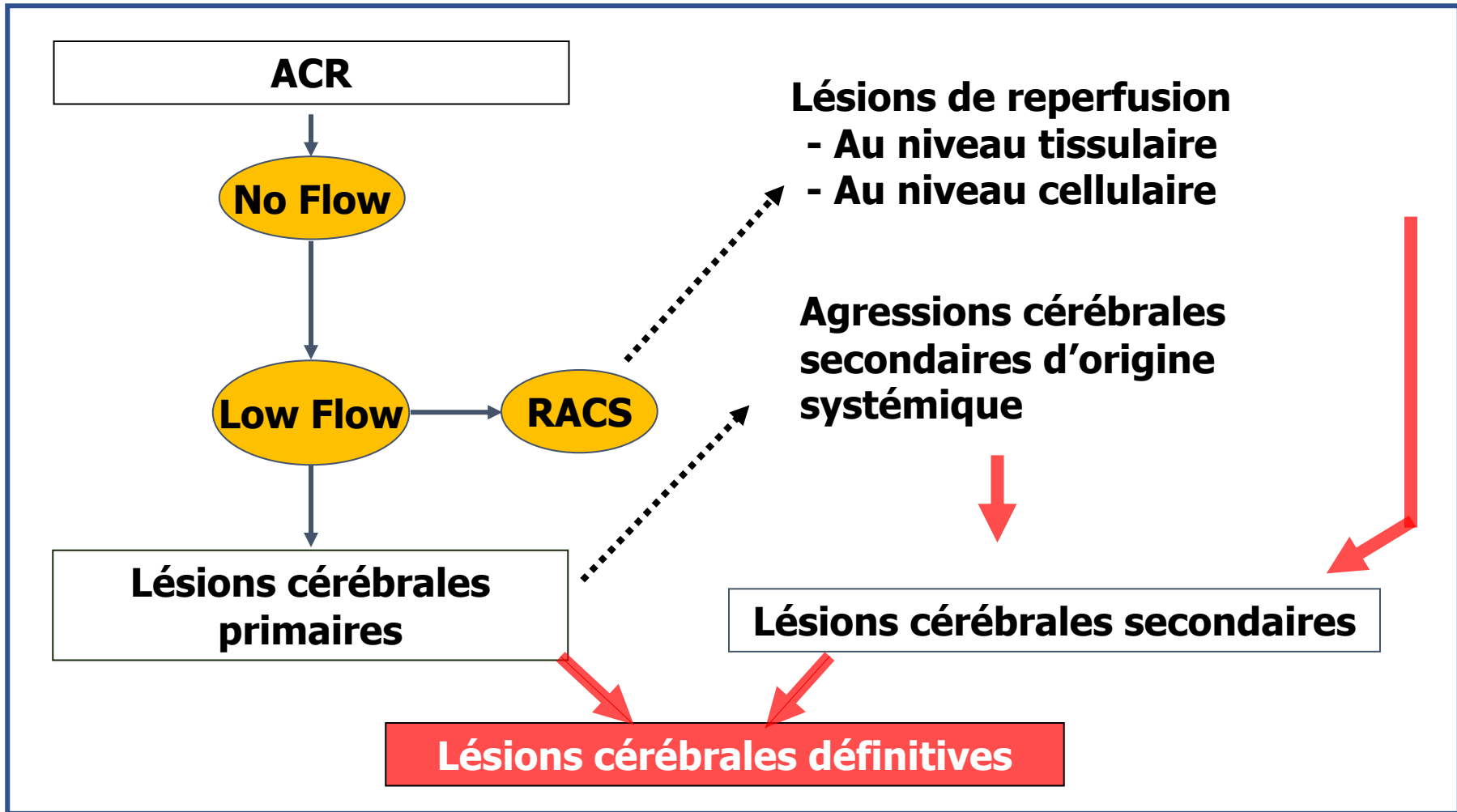
- Choc et défaillances d'organes
- Lésions cérébrales post-anoxiques

# ICU mortality after cardiac arrest: the relative contribution of shock and brain injury in a large cohort



# EVALUER L'ÉTAT NEUROLOGIQUE POST-ACR





# Intensive care medicine research agenda on cardiac arrest

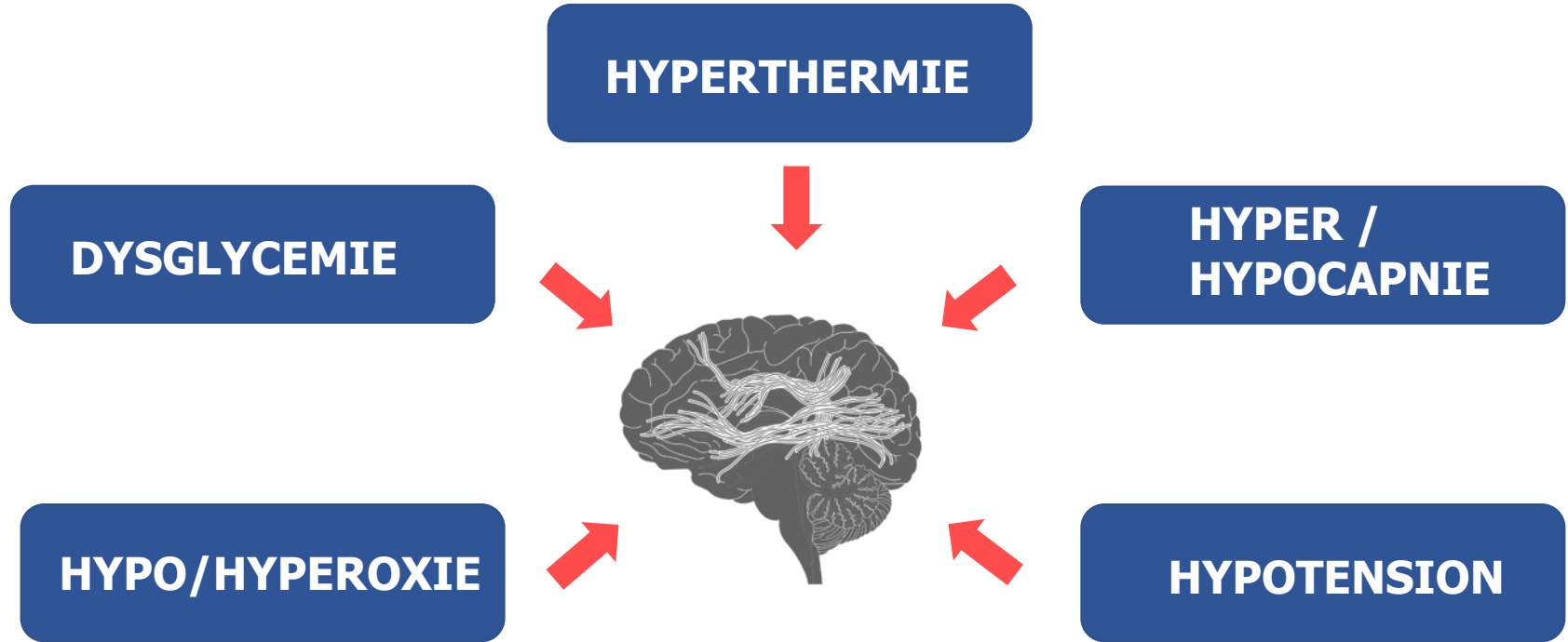
Jerry P. Nolan<sup>1,2\*</sup>, Robert A. Berg<sup>3,4</sup>, Stephen Bernard<sup>5</sup>, Bentley J. Bobrow<sup>6</sup>, Clifton W. Callaway<sup>7</sup>, Tobias Cronberg<sup>8</sup>, Rudolph W. Koster<sup>9</sup>, Peter J. Kudenchuk<sup>10</sup>, Graham Nichol<sup>11</sup>, Gavin D. Perkins<sup>12</sup>, Tom D. Rea<sup>13</sup>, Claudio Sandroni<sup>14</sup>, Jasmeet Soar<sup>15</sup>, Kjetil Sunde<sup>16,17</sup> and Alain Cariou<sup>18</sup>

## Neuroprotective drugs after cardiac arrest



# AGRESSIONS CÉRÉBRALES SECONDAIRES D'ORIGINE SYSTEMIQUE

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# COMMENT GÉRER LA PaCO<sub>2</sub> APRÈS UN ARRÊT CARDIAQUE ?

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SaO<sub>2</sub> = 94-98%

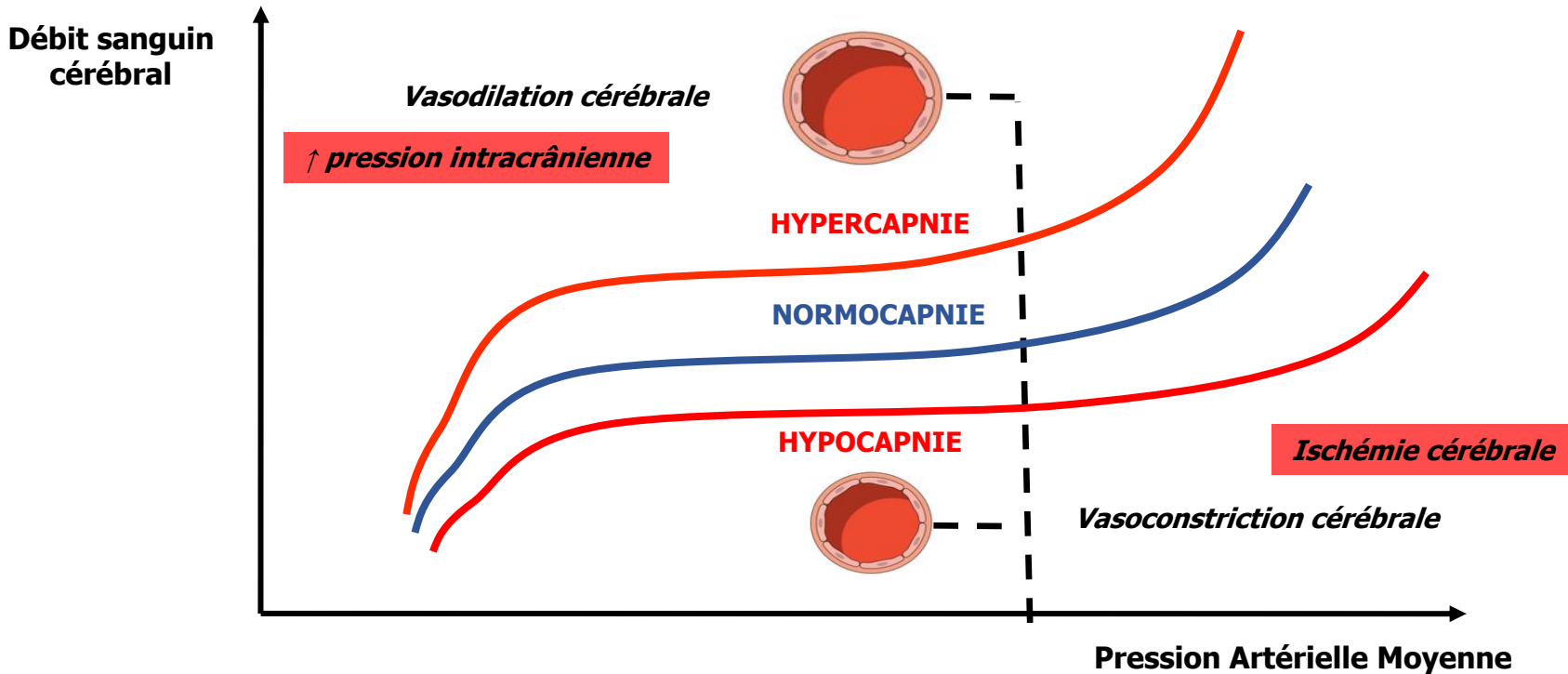
PaCO<sub>2</sub> ?

Glycémie ?

PA ?

Température ?

# DÉBIT SANGUIN CÉRÉBRAL ET PaCO<sub>2</sub>



SaO<sub>2</sub> = 94-98%

PaCO<sub>2</sub> ?

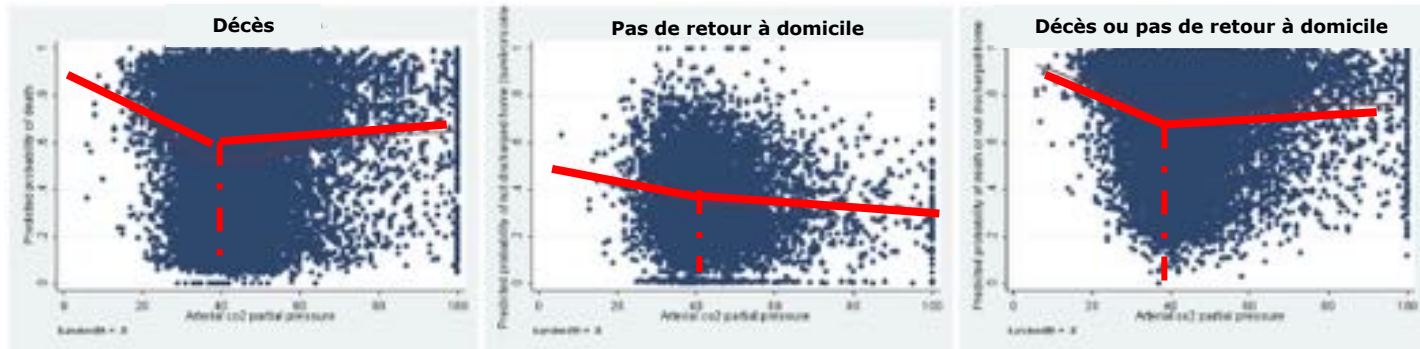
Glycémie ?

PA ?

Température ?

# PaCO<sub>2</sub> ET DEVENIR NEUROLOGIQUE EN POST ACR

16,542 ACR dans 125 réanimations entre 2000 et 2011  
18% hypocapnie // 41% d'hypercapnie



**L'hypocapnie après ACR est délétère**

L'hypercapnie > 45 mmHg n'est pas significativement associée à la mortalité hospitalière (et serait même associée à un retour à domicile chez les survivants)

*Schneider et al, Resuscitation, 2013*

SaO<sub>2</sub> = 94-98%

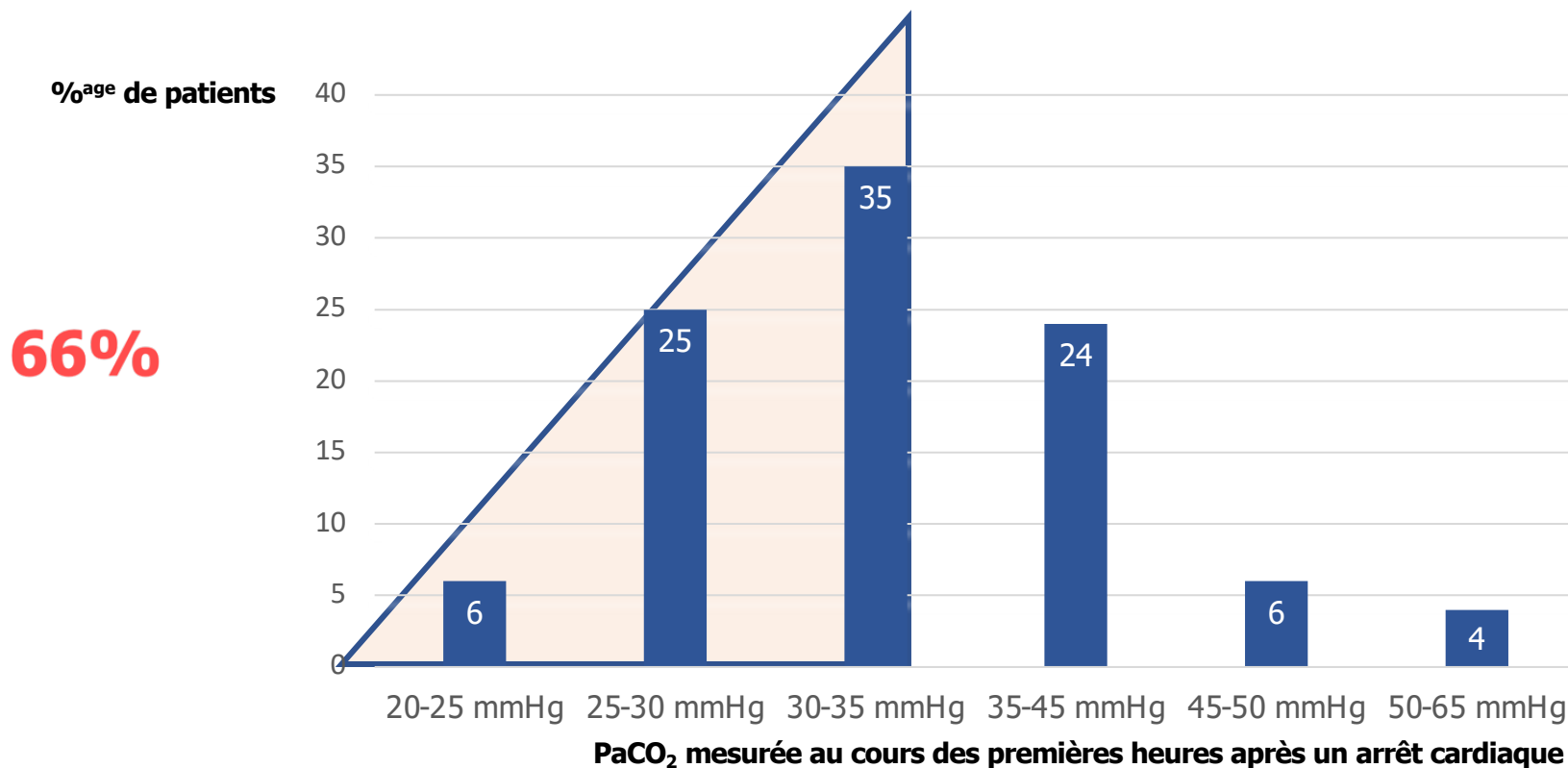
PaCO<sub>2</sub> ?

Glycémie ?

PA ?

Température ?

# ET POURTANT...



SaO<sub>2</sub> = 94-98%

PaCO<sub>2</sub> ?

Glycémie ?

PA ?

Température ?

**HYPERVENTILATION**  
(réglages de la FR et du Vt)

**HYPOTHERMIE**



**HYPOCAPNIE  
IATROGÈNE**



**SaO<sub>2</sub> = 94-98%**

**PaCO<sub>2</sub> ?**

**Glycémie ?**

**PA ?**

**Température ?**

## Part 3: Adult Basic and Advanced Life Support

### 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Recommendations for Oxygenation and Ventilation After ROSC		
COR	LOE	Recommendations
1	B-NR	1. We recommend avoiding hypoxemia in all patients who remain comatose after ROSC.
2b	B-R	2. Once reliable measurement of peripheral blood oxygen saturation is available, avoiding hyperoxemia by titrating the fraction of inspired oxygen to target an oxygen saturation of 92% to 98% may be reasonable in patients who remain comatose after ROSC.
2b	B-R	3. Maintaining the arterial partial pressure of carbon dioxide ( $P_{aCO_2}$ ) within a normal physiological range (generally 35–45 mm Hg) may be reasonable in patients who remain comatose after ROSC.

## RECOMMANDATIONS 2021 :



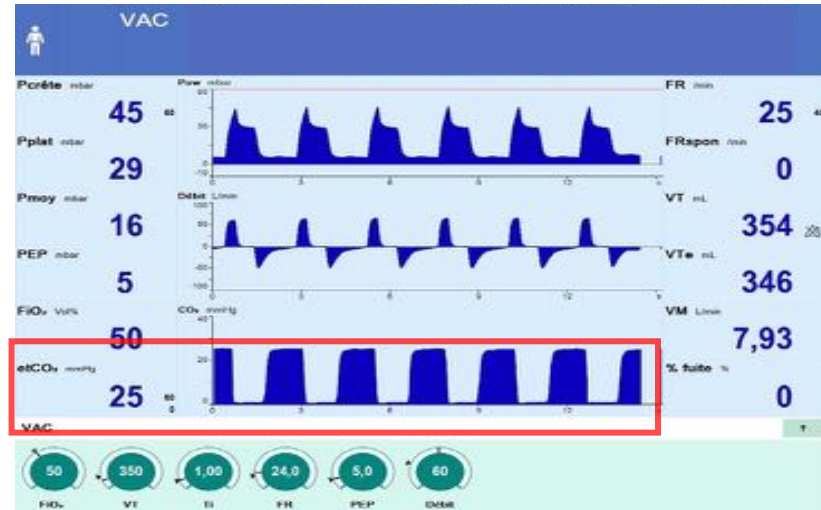
### ERC/ESICM:

**Cibler une PaCO<sub>2</sub> normale**

**Eviter l'hypocapnie +++**

**Surveiller GdS artériel**

**Monitorer l'EtCO<sub>2</sub>** →



SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

Glycémie ?

PA ?

Température ?

# COMMENT GÉRER LA PRESSION ARTÉRIELLE APRÈS UN ARRÊT CARDIAQUE ?

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SaO<sub>2</sub> = 94-98%

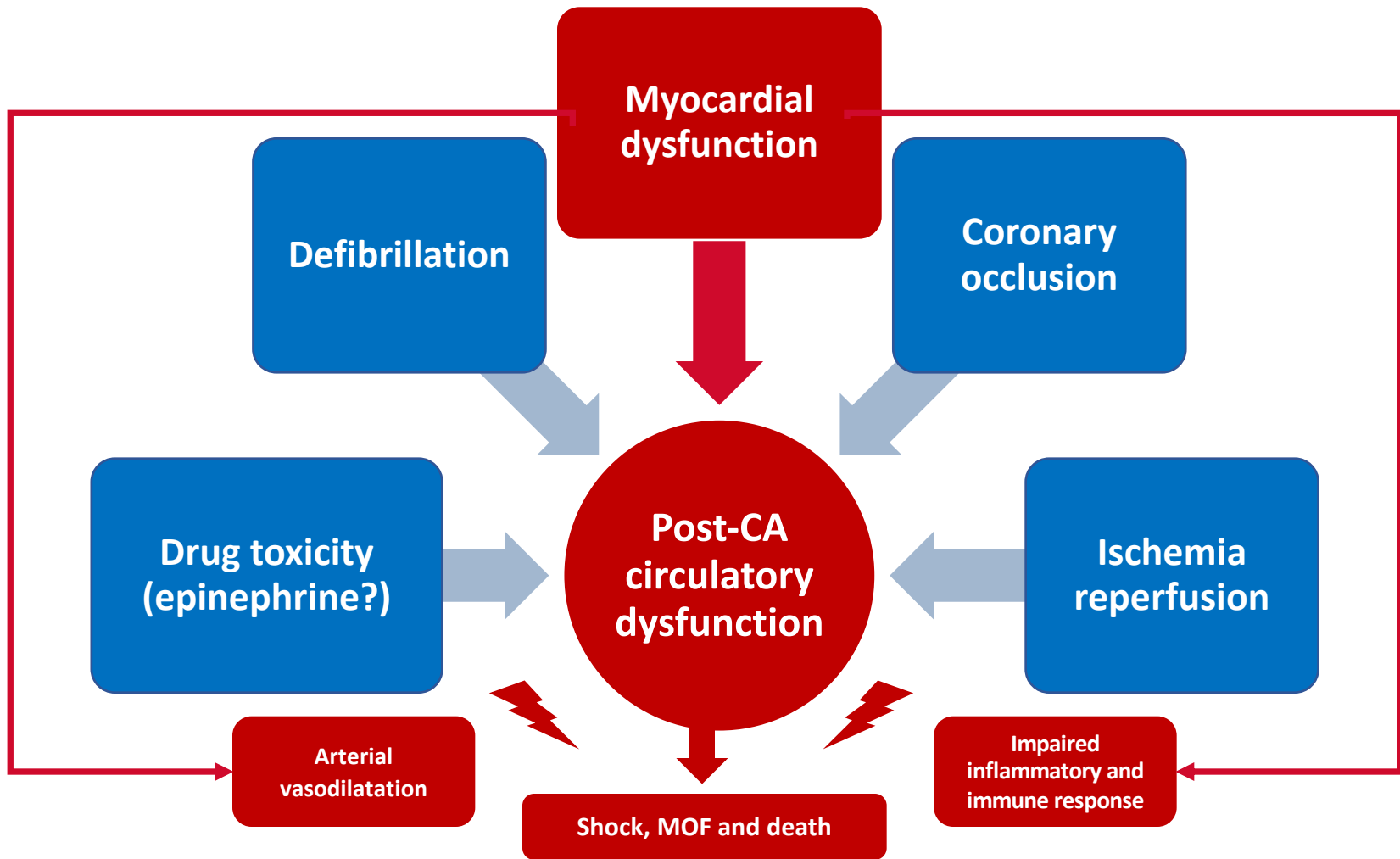
Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PA ?

Température ?





**Myocardial dysfunction**

**Defibrillation**

**Coronary occlusion**

**Drug toxicity (epinephrine?)**

**Post-CA circulatory dysfunction**

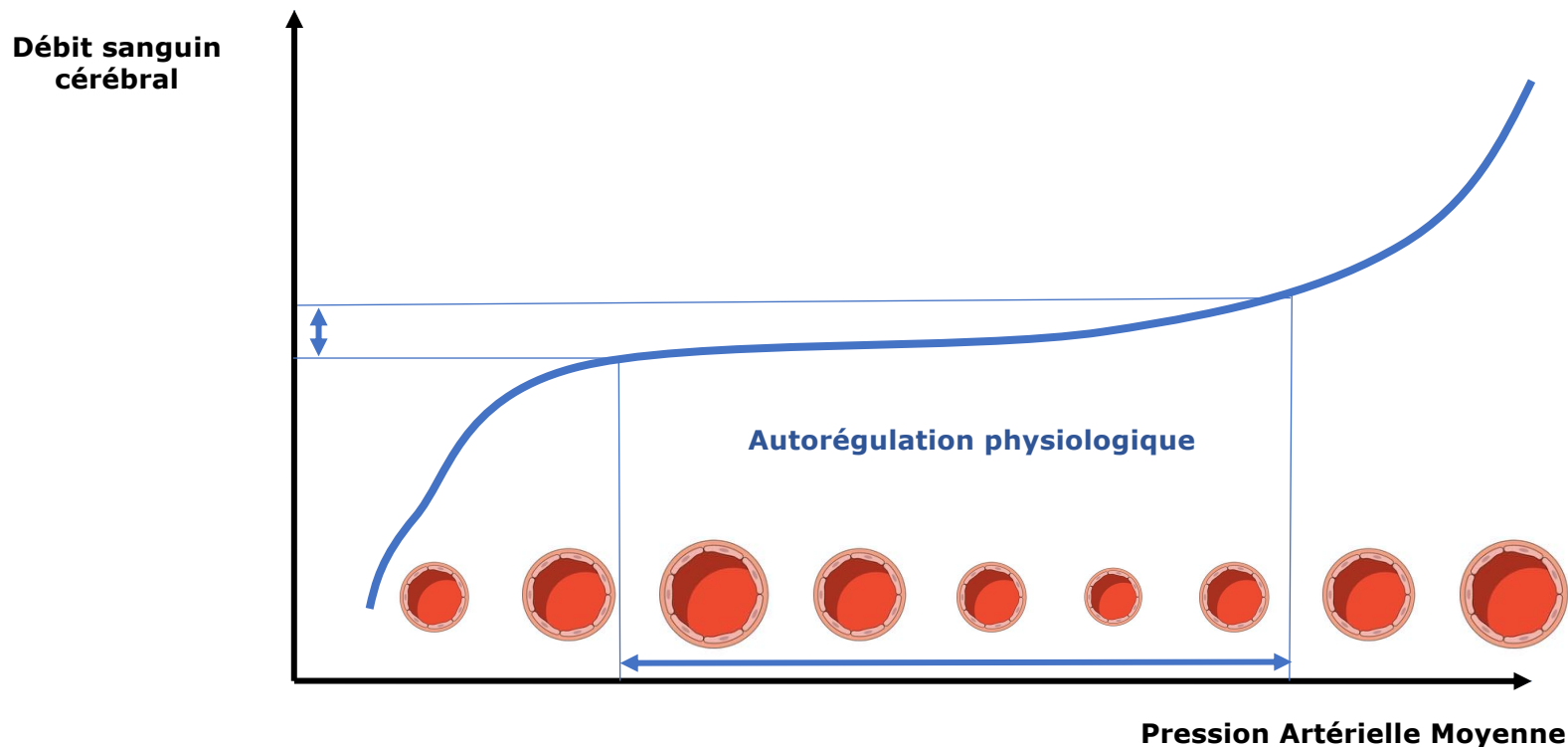
**Ischemia reperfusion**

**Arterial vasodilatation**

**Shock, MOF and death**

**Impaired inflammatory and immune response**

# REGULATION DU DEBIT SANGUIN CEREBRAL



SaO<sub>2</sub> = 94-98%

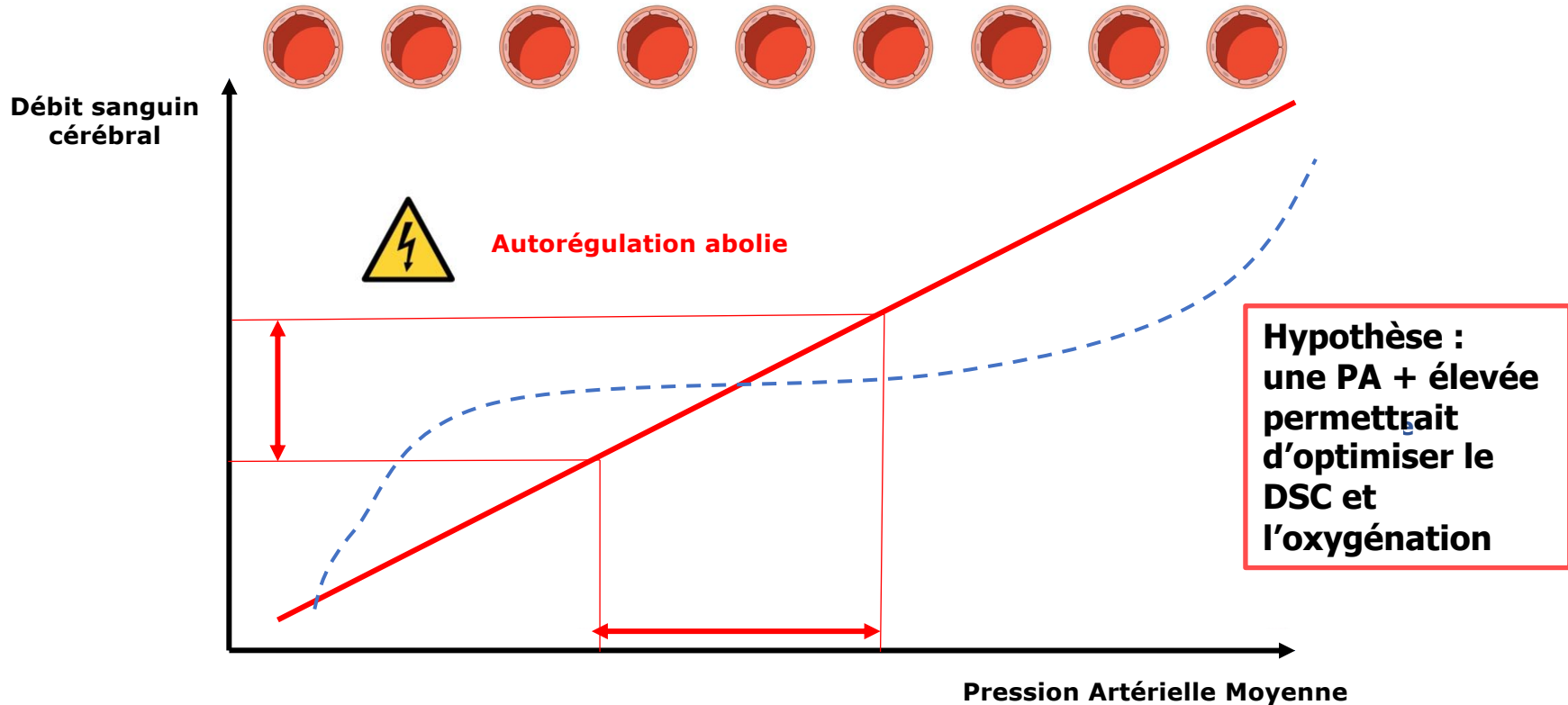
Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PA ?

Température ?

# RÉGULATION DU DÉBIT SANGUIN CÉRÉBRAL



SaO<sub>2</sub> = 94-98%

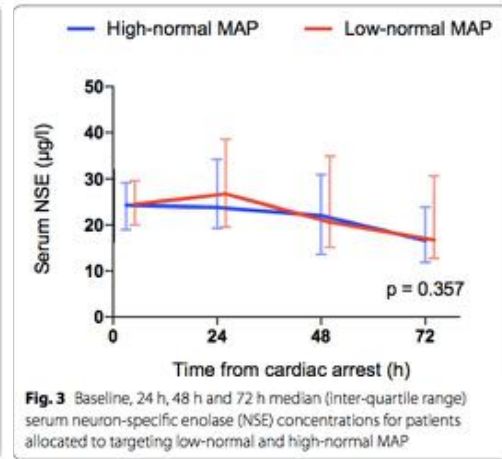
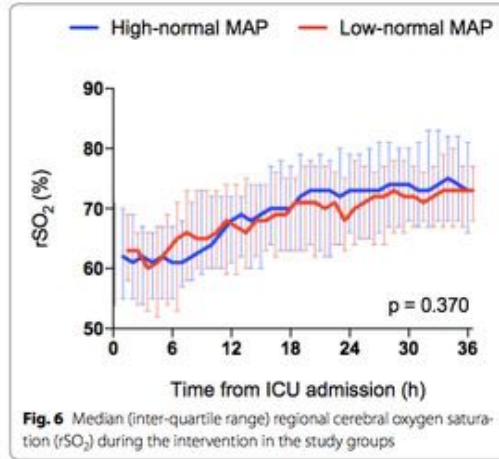
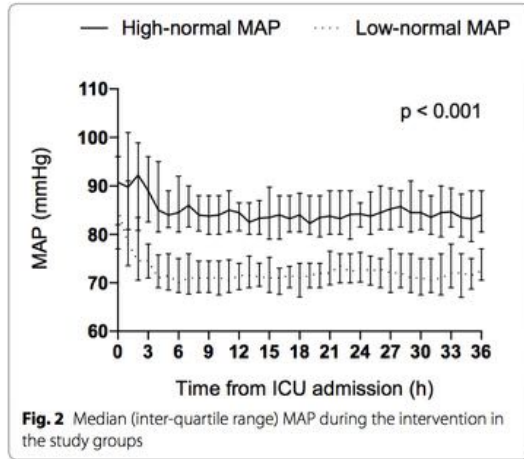
Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PA ?

Température ?

# Targeting low-normal or high-normal mean arterial pressure after cardiac arrest and resuscitation: a randomised pilot trial



*Jakkula P et al. Intensive Care Med 2018*

SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

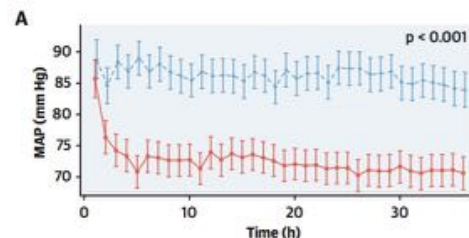
HGT < 10 mmol/l

PA ?

Température??

# Optimum Blood Pressure in Patients With Shock After Acute Myocardial Infarction and Cardiac Arrest

Ameloot K et al. JACC 2020



**TABLE 3** Study Endpoints

	MAP 80/85 to 100 mm Hg	MAP 65 mm Hg	Treatment Effect	p Value*
<b>Primary endpoint</b>				
Imputed 72 h AUC cTnT, $\mu\text{g}\cdot\text{h/l}$	1.14 (0.35 to 2.31)	1.56 (0.61 to 4.72)	-0.42 (-1.12 to 0.00)	0.04
<b>Secondary endpoints</b>				
New onset atrial fibrillation	4/58 (7)	4/61 (7)	1.05 (0.25 to 4.43)	0.94
Recurrent cardiac arrest within 36 h	8/58 (14)	9/61 (15)	0.92 (0.33 to 2.58)	0.88
CPC 1 to 2 180 days	37/58 (64)	33/62 (53)	1.55 (0.74 to 3.22)	0.24
All-cause mortality 180 days	21/58 (36)	25/62 (40)	0.84 (0.40 to 1.75)	0.63

Values are mean (interquartile range) or n/N (%). \*p values for all secondary endpoints are exploratory.  
 AUC = area under curve; cTnT = Cardiac troponin T; CPC = cerebral performance category; IQR = interquartile range.

## Part 3: Adult Basic and Advanced Life Support

2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Recommendation for Blood Pressure Management After ROSC		
COR	LOE	Recommendation
2a	B-NR	1. It is preferable to avoid hypotension by maintaining a systolic blood pressure of at least 90 mm Hg and a mean arterial pressure of at least 65 mm Hg in the postresuscitation period.

## RECOMMANDATIONS 2021 :



### ERC/ESICM :

**Cibler une PAM > 65 mmHg**

*(recours aux amines vasopressives  
type NAD si besoin)*

**Monitoring invasif de la PA**



SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?

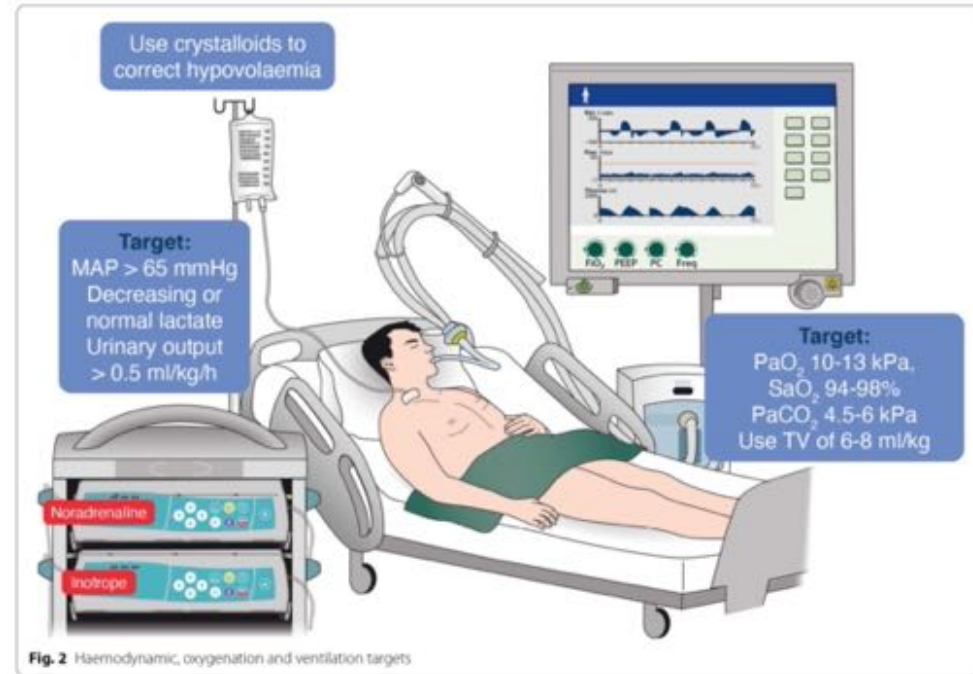


# European Resuscitation Council and European Society of Intensive Care Medicine guidelines 2021: post-resuscitation care

Jerry P. Nolan<sup>1,2\*</sup>, Claudio Sandroni<sup>3,4</sup>, Bernd W. Böttiger<sup>5</sup>, Alain Cariou<sup>6</sup>, Tobias Cronberg<sup>7</sup>, Hans Friberg<sup>8</sup>, Cornelia Genbrugge<sup>9,10</sup>, Kirstie Haywood<sup>11</sup>, Gisela Lilja<sup>12</sup>, Véronique R. M. Moolaert<sup>13</sup>, Nikolaos Nikolaou<sup>14</sup>, Theresa Mariero Olasveengen<sup>15</sup>, Markus B. Skrifvars<sup>16</sup>, Fabio Taccone<sup>17</sup> and Jasmeet Soar<sup>18</sup>

## Key messages

- Continuous monitoring (arterial line +/- CO)
- Echocardiography (as soon as possible) in all pts
- Avoid hypotension <65 mmHg
- Target MAP to achieve adequate urine output (>0.5 mL kg<sup>-1</sup> h<sup>-1</sup>) and normal or decreasing lactate
- Don not treat bradycardia induced by TTM if BP, lactate, or SvO<sub>2</sub> is adequate
- Maintain perfusion with fluids, noradrenaline and/or dobutamine, depending on individual patient need
- Do not give steroids routinely





# COMMENT GÉRER LA TEMPÉRATURE APRÈS UN ARRÊT CARDIAQUE ?

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???

SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?

# PRIORITÉ: EMPÊCHER LA FIÈVRE !!!

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- ↑ **excitation neuronale**
- ↑ **production de radicaux libres**
- ↑ **besoins métaboliques**
- ↑ **inflammation**
- ↑ **pression intra-crânienne**



## AGGRAVATION DES LESIONS CEREBRALES

SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?

# The New England Journal of Medicine

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VOLUME 346

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NUMBER 8



## MILD THERAPEUTIC HYPOTHERMIA TO IMPROVE THE NEUROLOGIC OUTCOME AFTER CARDIAC ARREST

THE HYPOTHERMIA AFTER CARDIAC ARREST STUDY GROUP\*

## TREATMENT OF COMATOSE SURVIVORS OF OUT-OF-HOSPITAL CARDIAC ARREST WITH INDUCED HYPOTHERMIA

STEPHEN A. BERNARD, M.B., B.S., TIMOTHY W. GRAY, M.B., B.S., MICHAEL D. BUIST, M.B., B.S.,  
BRUCE M. JONES, M.B., B.S., WILLIAM SILVESTER, M.B., B.S., GEOFF GUTTERIDGE, M.B., B.S., AND KAREN SMITH, B.Sc.

**SaO<sub>2</sub> = 94-98%**

**Surv. EtCO<sub>2</sub>**

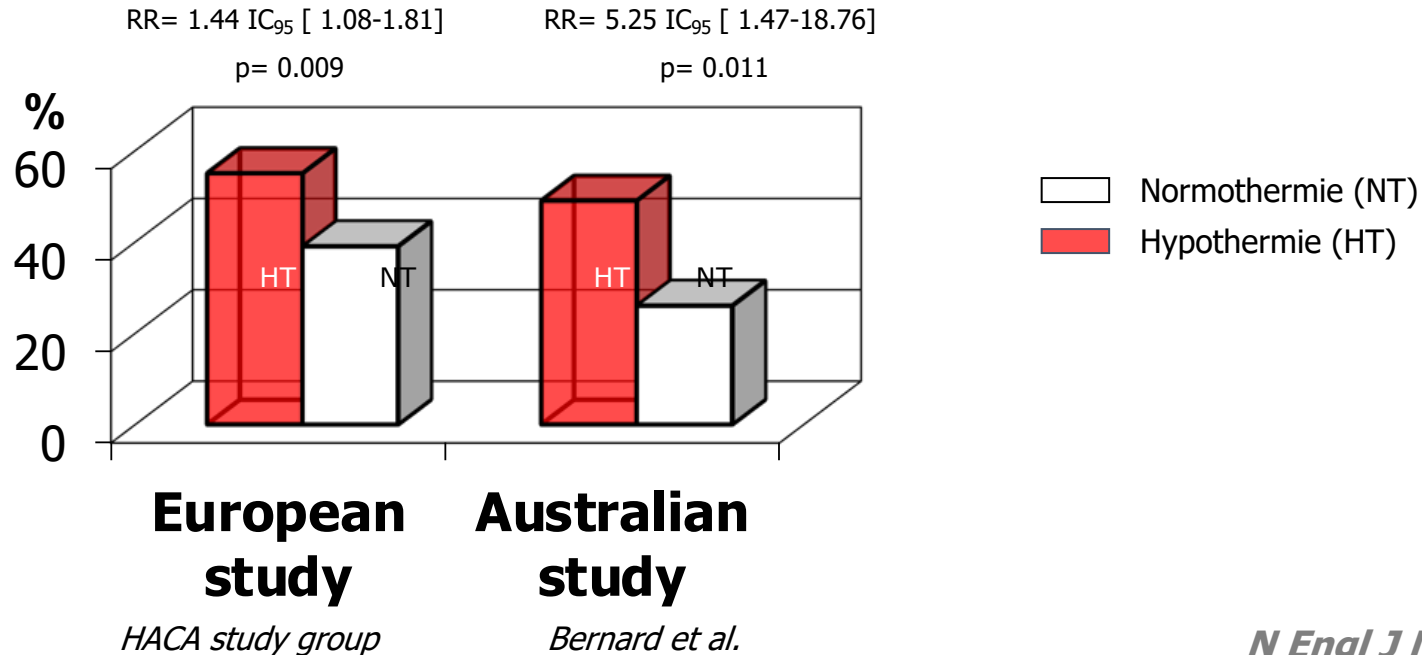
**HGT < 10 mmol/l**

**PAM > 65 mmHg**

**Température ?**

# HYPOTHERMIE APRÈS ACR: ÉTUDES PIVOTS

## CPC 1 ou 2 (à 6 mois)



SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?

*N Engl J Med 346, 2002*

# HYPOTHERMIE POST ACR

---

**+ vite ?**

**+ tôt ?**

**+ froid ?**

**+ longtemps ?**

**+ sélectif ?**

**+ précis ?**

**+ prudent ?**



**SaO<sub>2</sub> = 94-98%**

**Surv. EtCO<sub>2</sub>**

**HGT < 10 mmol/l**

**PAM > 65 mmHg**

**Température ?**

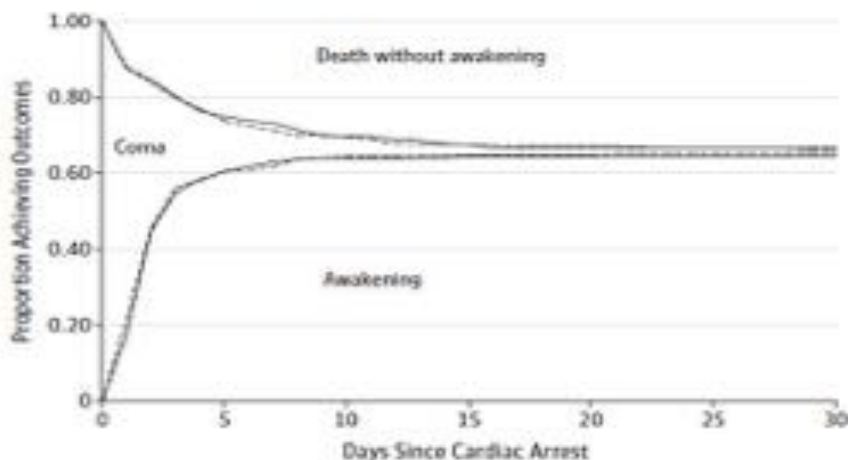
Original Investigation

# Effect of Prehospital Induction of Mild Hypothermia on Survival and Neurological Status Among Adults With Cardiac Arrest A Randomized Clinical Trial

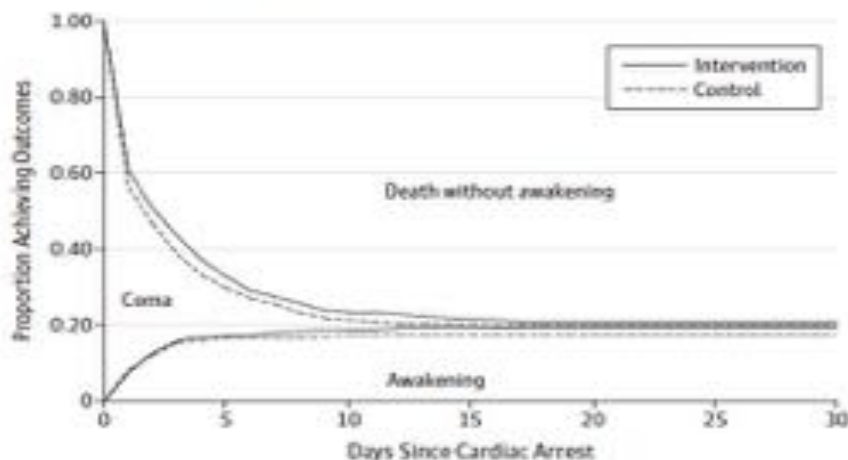
JAMA. doi:10.1001/jama.2013.282173  
Published online November 17, 2013.

Francis Kim, MD; Graham Nichol, MD, MPH; Charles Maynard, PhD; Al Hallstrom, PhD; Peter J. Kudenchuk, MD; Thomas Rea, MD, MPH; Michael K. Copass, MD; David Carlborn, MD; Steven Deem, MD; W. T. Longstreth Jr, MD; Michele Olsufka, RN; Leonard A. Cobb, MD

**A** With ventricular fibrillation



**B** Without ventricular fibrillation

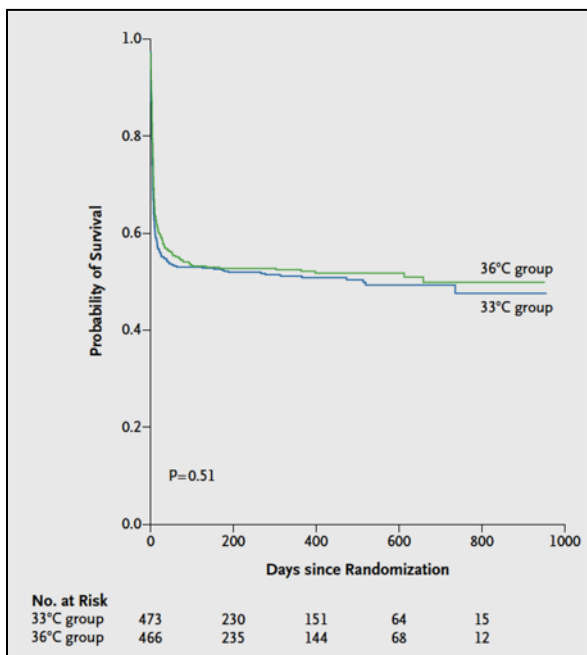


	Intervention (n=686)	Control (n=671)	P value
Re-arrest post-randomization	176 (26)	138 (21)	.008



# Targeted Temperature Management at 33°C versus 36°C after Cardiac Arrest

Nielsen N. NEJM 2013



Variable	33°C Group	36°C Group
<b>CPC at follow-up†</b>		
Total no. of patients	469	464
<b>Category — no. (%)</b>		
1	195 (42)	183 (39)
2	23 (5)	39 (8)
3	17 (4)	20 (4)
4	6 (1)	2 (0.5)
5	228 (49)	220 (47)
P value for trend	0.85	

SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?

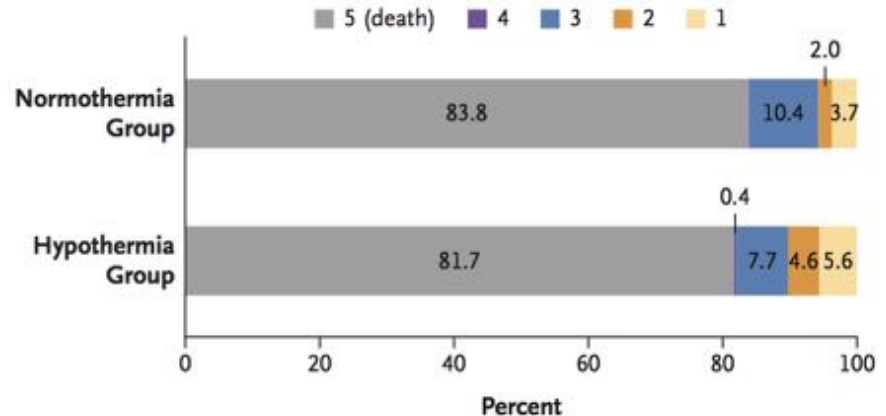
Lascarrou JB et al. NEJM 2019

## Targeted Temperature Management for Cardiac Arrest with Nonshockable Rhythm

- Open-label, randomized, controlled trial
- Moderate therapeutic hypothermia (33°C during the first 24 hours) versus targeted normothermia (37°C)
- Comatose patients admitted to the ICU after resuscitation from cardiac arrest with **non-shockable** rhythm
- Primary outcome: survival with a favorable neurologic outcome (CPC score of 1 or 2)

**Table 2. Neurologic Outcomes and Hospitalization Characteristics.<sup>o</sup>**

Outcome	Hypothermia (N = 284)	Normothermia (N = 297)	Difference or Hazard Ratio (95% CI)
CPC score of 1 or 2 on day 90 — no. (%)	29 (10.2)	17 (5.7)	4.5 (0.1 to 8.9) †

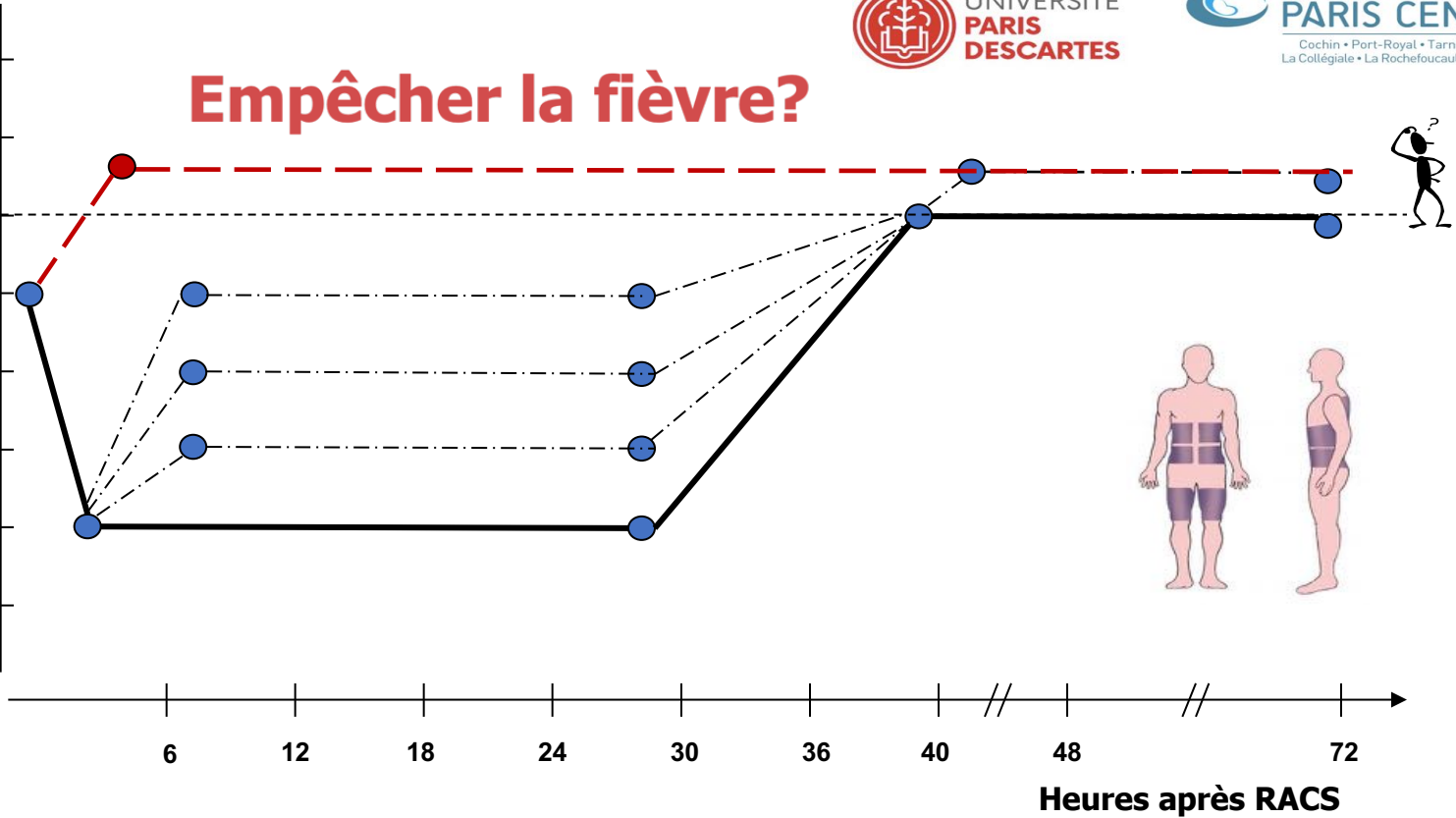




Temperature

39  
38  
37  
36  
35  
34  
33  
32

# Empêcher la fièvre?



SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?



ACREH

**Résultats ... bientôt**

<37.8°C

**Mortalité à 6 mois**  
Etat neurologique à 6 mois  
Pronostic neurocognitif à 24 mois

1900/1900  
100% Cor

Randomisation Complete!



SaO<sub>2</sub> = 94-98%

Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

Température ?

## Part 3: Adult Basic and Advanced Life Support

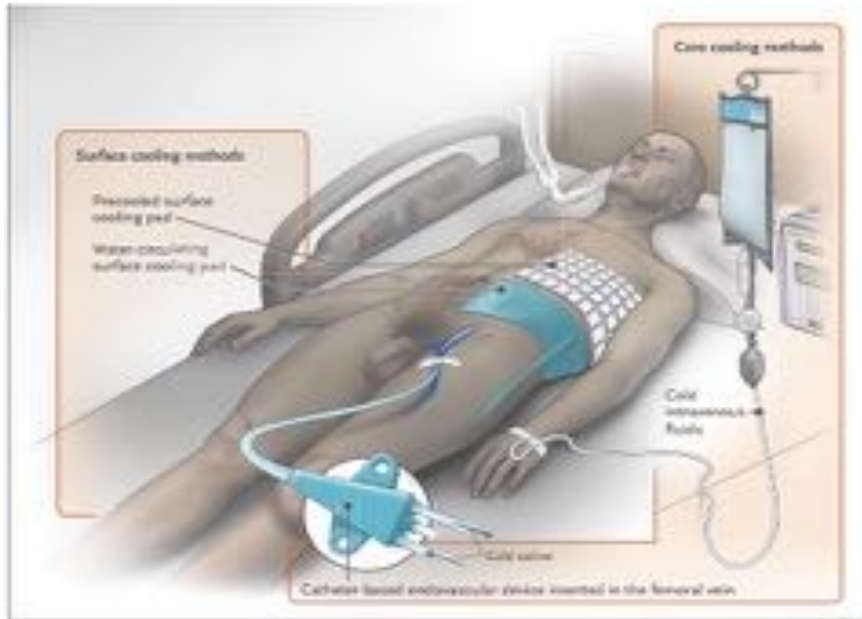
2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Recommendations for Indications for TTM		
COR	LOE	Recommendations
1	B-R	1. We recommend TTM for adults who do not follow commands after ROSC from OHCA with any initial rhythm.
1	B-R	2. We recommend TTM for adults who do not follow commands after ROSC from IHCA with initial nonshockable rhythm.
1	B-NR	3. We recommend TTM for adults who do not follow commands after ROSC from IHCA with initial shockable rhythm.

Recommendations for Performance of TTM		
COR	LOE	Recommendations
1	B-R	1. We recommend selecting and maintaining a constant temperature between 32°C and 36°C during TTM.
2a	B-NR	2. It is reasonable that TTM be maintained for at least 24 h after achieving target temperature.
2b	C-LD	3. It may be reasonable to actively prevent fever in comatose patients after TTM.
3: No Benefit	A	4. We do not recommend the routine use of rapid infusion of cold IV fluids for prehospital cooling of patients after ROSC.

# COMMENT ?

**R6.1 - Chez les patients traités par CCT, il faut utiliser des méthodes asservies à la température corporelle par comparaison aux méthodes non asservies dans le but d'améliorer la qualité du CCT. (Grade 1+) Accord FORT**



SaO<sub>2</sub> = 94-98%

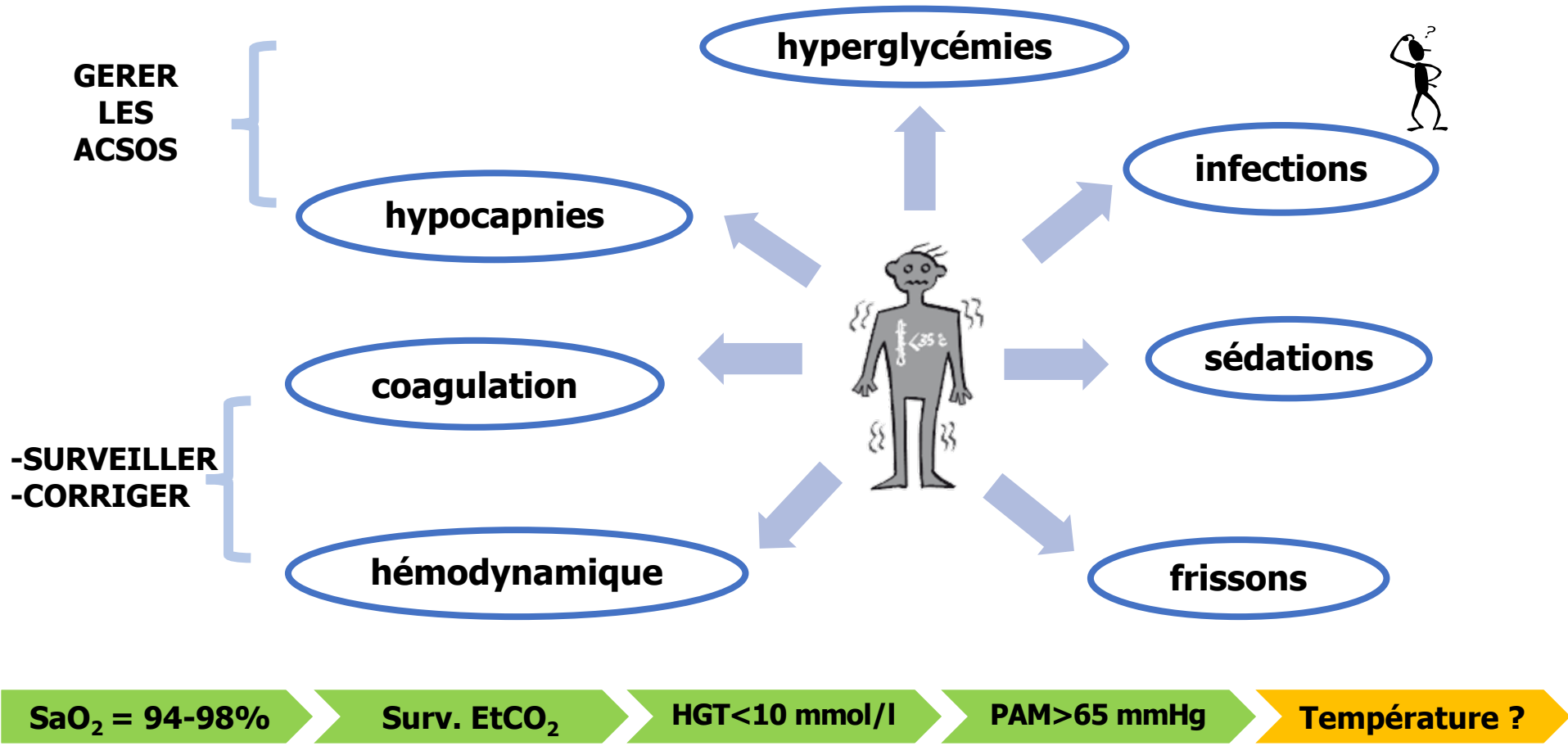
Surv. EtCO<sub>2</sub>

HGT < 10 mmol/l

PAM > 65 mmHg

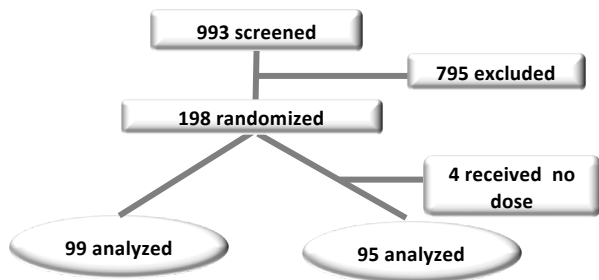
Température ?

# SURVEILLANCE DU CCT

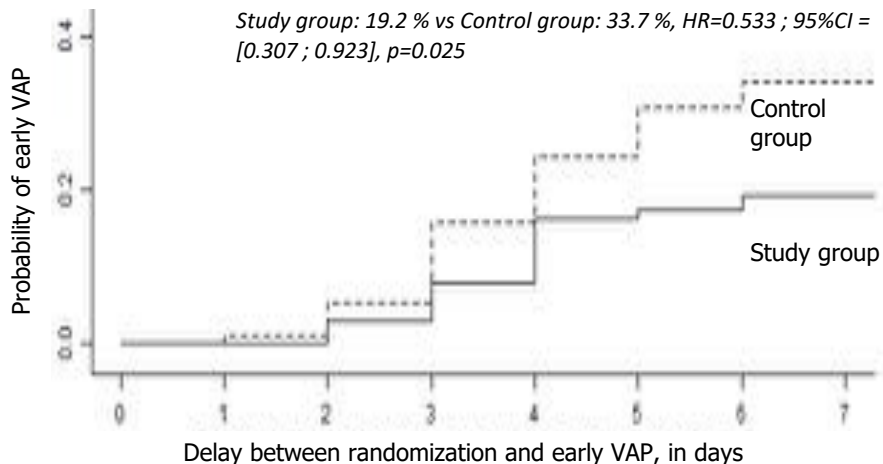


# Short term antibiotics prevent early VAP in patients treated with mild therapeutic hypothermia after cardiac arrest. The ANTHARTIC trial

*T Daix<sup>1</sup> ; A Cariou<sup>2</sup> ; F Meziani<sup>3</sup> ; PF Dequin<sup>4</sup> ; C Guitton<sup>5</sup> ; N Deye<sup>6</sup> ; G Plantefève<sup>7</sup> ; JP Quenot<sup>8</sup> ; A Desachy<sup>9</sup> ; T Kamei<sup>10</sup> ; S Bedon-Cardet<sup>11</sup> ; JL Diehl<sup>12</sup> ; N Chudeau<sup>13</sup> ; E Karam<sup>14</sup> ; F Renon-Carron<sup>15</sup> ; A Hernandez Padilla<sup>1</sup> ; P Vignon<sup>1</sup> ; A Le Gouge<sup>16</sup> ; B François<sup>1</sup>*



	Study group (n=99)	Control group (n=95)
Age, years	60.6 ± 14.3	60.3 ± 14.6
Man	76 (76.8)	80 (84.2)
No-flow duration, min	2.0 [0.0 ; 5.0]	3.0 [0.0 ; 5.5]
Low-flow duration, min	20.0 [10.0 ; 28.0]	18.0 [11.5 ; 24.5]
SOFA	8.8 ± 3.2	8.5 ± 3.0
APACHE II	24.7 ± 5.7	23.8 ± 5.7



**Une courte antibioprophylaxie serait significativement associée à une diminution du taux de PAVM chez les patients sous CCT**

**SaO<sub>2</sub> = 94-98%**

**Surv. EtCO<sub>2</sub>**


**HGT < 10 mmol/l**

**PAM > 65 mmHg**


**Température ?**

# NEUROPROTECTION POST-ARRET CARDIAQUE


## Oxygénation

-  hyperoxie
- Alarmes SaO<sub>2</sub>= 94-98%


## Capnie

-  hypocapnie
- Monitorer EtCO<sub>2</sub>... et ajuster la ventilation!



## Glycémie

-  hypoglycémie
- Avec HGT <10 mmol/L

## Pression artérielle

-  hypotension (PAM > 65 mmHg +++)
- NAD si besoin

## Température

-  fièvre (CCT : 32 à 36°C)
-  effets indésirables et corriger