



Syndrome post-arrêt cardiaque

Pr Martin COUR

Médecine Intensive-Réanimation

Groupement Hospitalier Centre - Hospices Civils de Lyon

25 Novembre 2021

**Arrêts
cardiaques**



RCP : 60%



RACS : 30%



**Vivants sans
séquelle <10%**



Choc réfractaire : 30%

Lésions neuro / LATA : 60%

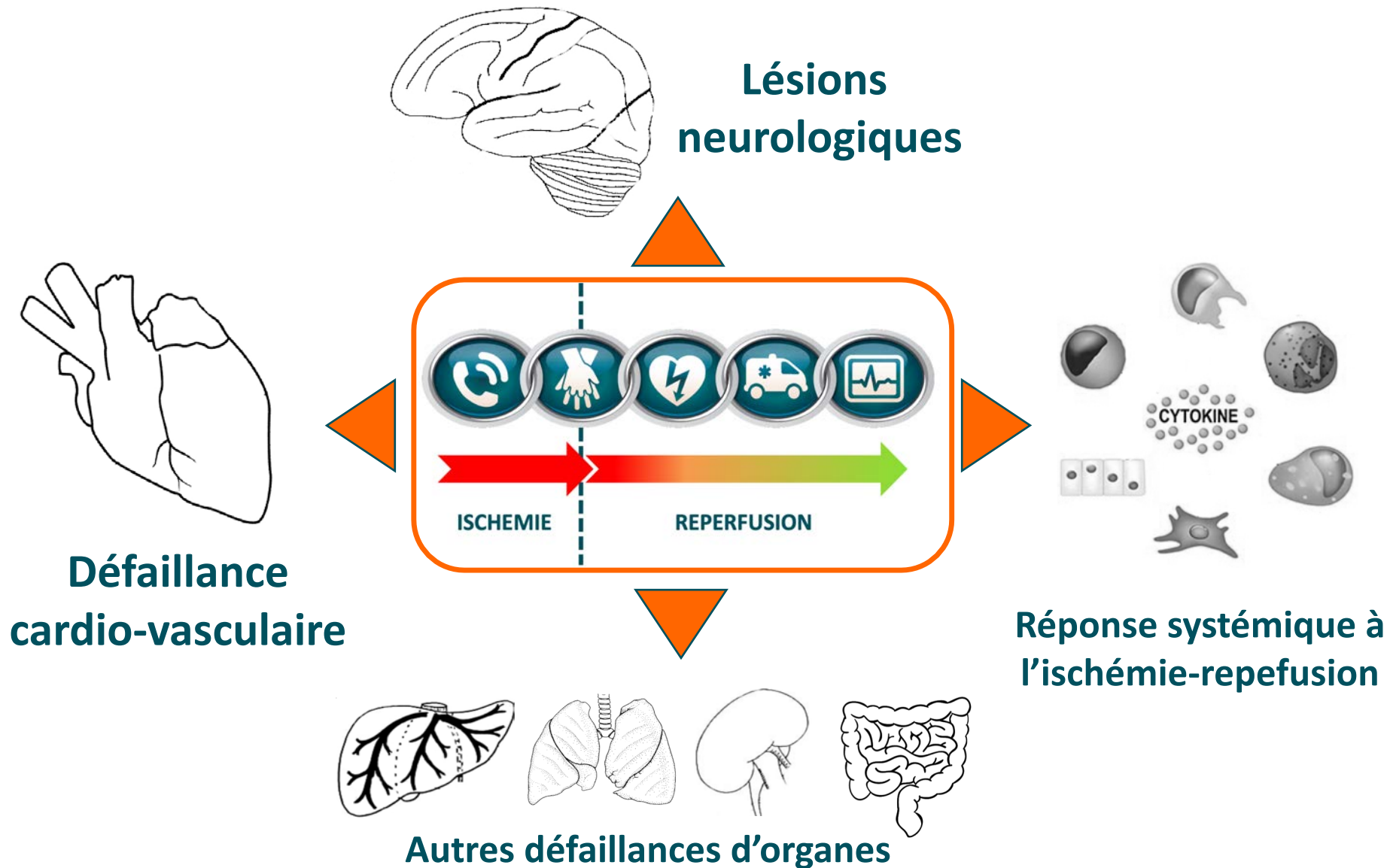
Mort encéphalique : 10%

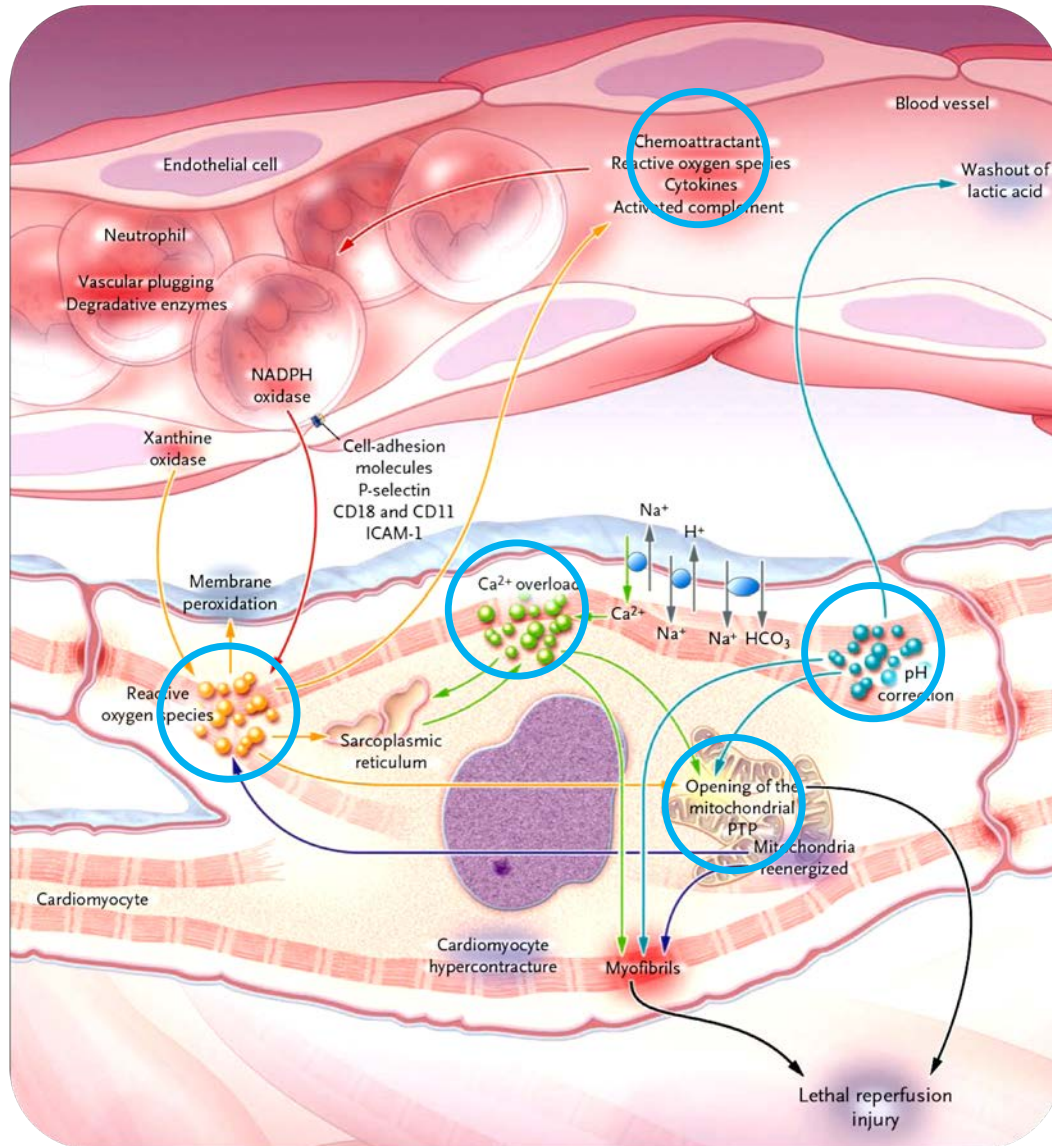
Potentiels donneurs d'organes



ISCHEMIE

REPERFUSION





Production de ROS

Surcharge calcique

Variation pH

Lésions mitochondriales

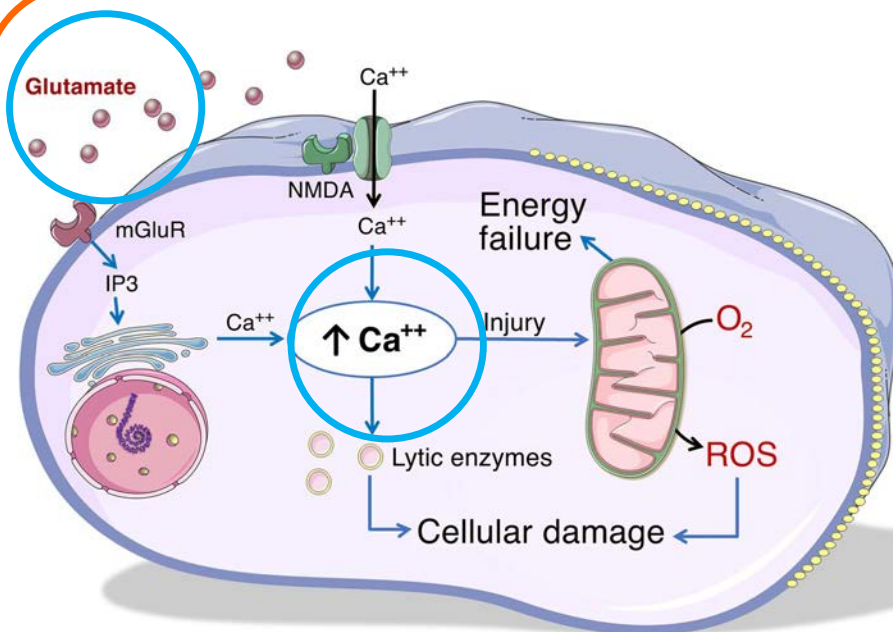
Inflammation



NARRATIVE REVIEW

Brain injury after cardiac arrest: pathophysiology, treatment, and prognosis

Claudio Sandroni^{1,2*}, Tobias Cronberg³ and Mypinder Sekhon⁴



No-reflow

Œdème cérébral / HTIC

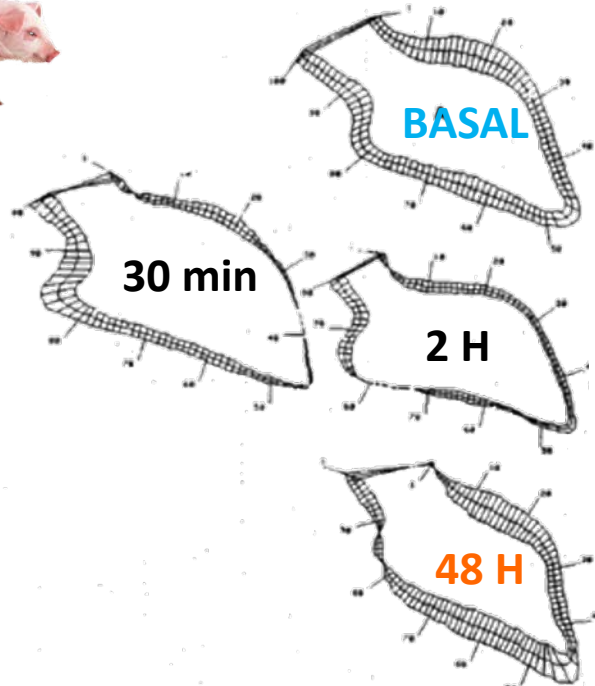
Perte de l'autorégulation

Convulsions

Inflammation



Sandroni C et al. *Intensive Care Med* 2021 (*in press*)



Kern KB et al. *Circulation* 1997;95:2610-3

FEVG (%)

50

25

BASAL

5 H post AC

Journal of the American College of Cardiology
© 2002 by the American College of Cardiology Foundation
Published by Elsevier Science Inc.

Vol. 40, No. 12, 2002
ISSN 0735-1097/02/\$22.00
PII S0735-1097(02)02594-9

Reversible Myocardial Dysfunction in Survivors of Out-of-Hospital Cardiac Arrest

Ivan Laurent, MD,* Mehran Monchi, MD,* Jean-Daniel Chiche, MD,* Luc-Marie Joly, MD,* Christian Spaulding, MD,‡ Bénédicte Bourgeois, MD,† Alain Cariou, MD,* Alain Rozenberg, MD,† Pierre Carli, MD,† Simon Weber, MD,‡ Jean-François Dhainaut, MD, PhD*

Paris, France

**Syndrome post-
arrêt cardiaque**

**Réponse
*sepsis like***

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

2002



Successful Cardiopulmonary Resuscitation After Cardiac Arrest as a "Sepsis-Like" Syndrome

Christophe Adrie, Minou Adib-Conquy, Ivan Laurent, Mehran Monchi, Christophe Vinsonneau, Catherine Fitting, François Fraisse, A. Tuan Dinh-Xuan, Pierre Carli, Christian Spaulding, Jean-François Dhainaut and Jean-Marc Cavaillon

**Syndrome post-
arrêt cardiaque****Réponse
*sepsis like*****Successful Cardiopulmonary Resuscitation After Cardiac Arrest as a "Sepsis-Like" Syndrome**

Cytokines and Receptors, pg/mL	OHCA Patients (n=61)	Patients With Sepsis (n=5)
TNF- α	16 (0–30)	16 (0–46)
sTNFRII	5714 (3629–8350)	4000 (7021–12 656)
IL-1ra	13 972 (1947–40 319)	72 897 (657–94 884)
IL-6	177 (53–355)	406 (390–4901)*
IL-8	67 (22–183)	399 (76–529)
IL-10	122 (41–250)	199 (160–1003)

**Syndrome post-
arrêt cardiaque**

**Dysfonction
immunitaire**

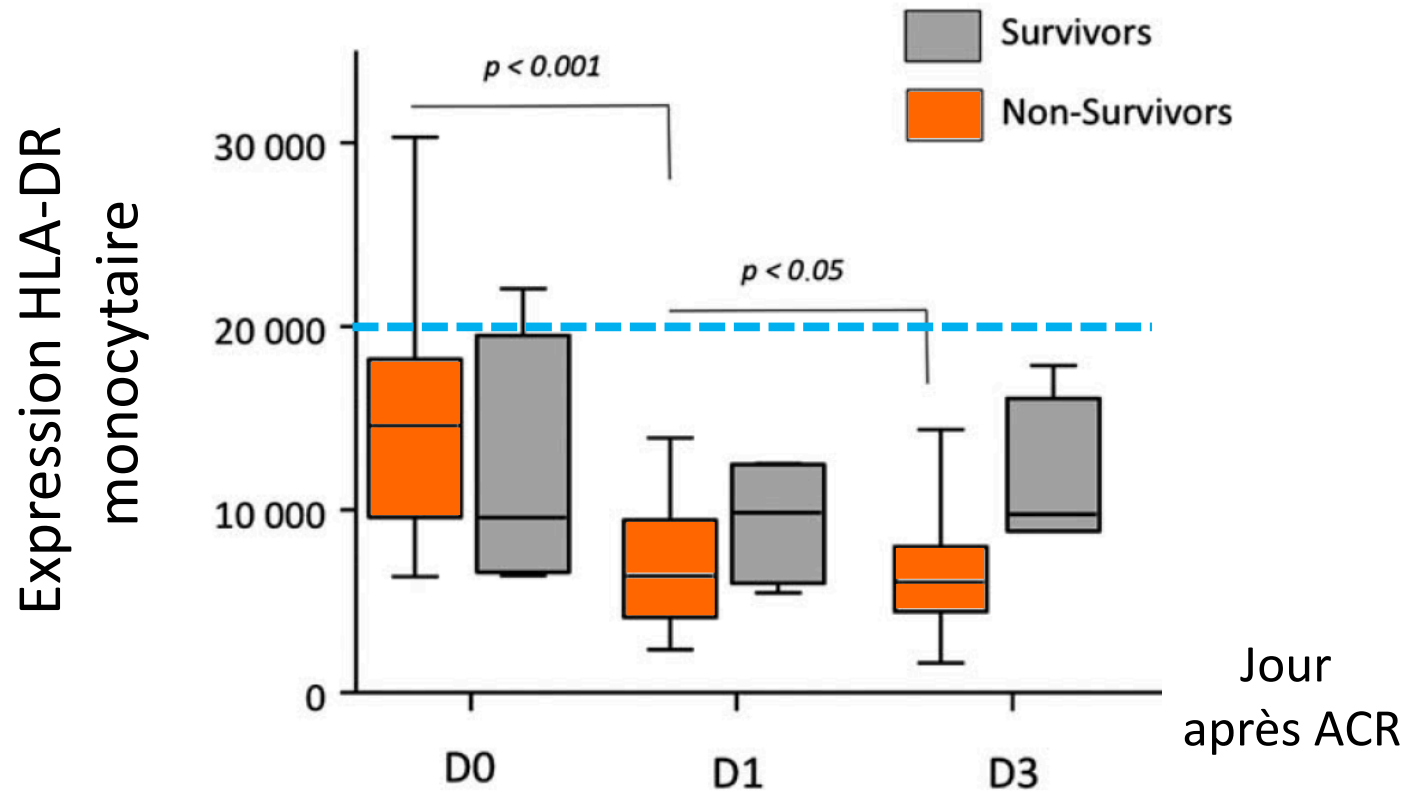
**DECREASED MONOCYTE HLA-DR EXPRESSION IN PATIENTS AFTER
NON-SHOCKABLE OUT-OF-HOSPITAL CARDIAC ARREST**

**Fabienne Venet,^{*†} Martin Cour,^{‡§} Julie Demaret,^{*†}
Guillaume Monneret,^{*†} and Laurent Argaud ^{‡§}**

SHOCK, Vol. 46, No. 1, pp. 33–36, 2016

Syndrome post-arrêt cardiaque

Dysfonction Immunitaire



Syndrome post-arrêt cardiaque

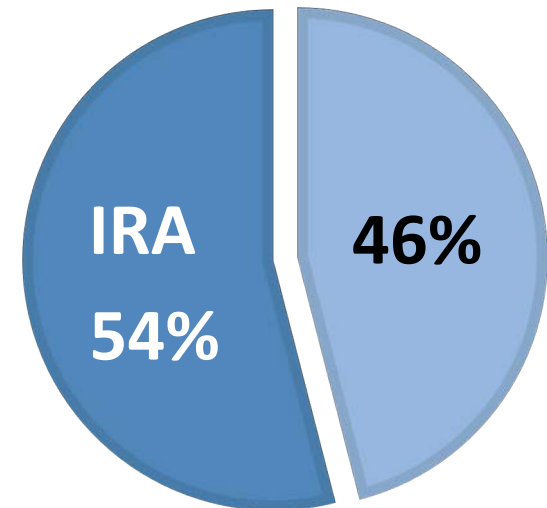
REIN

Acute kidney injury after cardiac arrest:
a systematic review and meta-analysis
of clinical studies

Claudio SANDRONI ^{1*}, Antonio M. DELL'ANNA ¹, Omar TUJJAR ²,
Guillaume GERI ³, Alain CARIOU ³, Fabio S. TACCONE ²

8 études - 1693 patients

Minerva Anesthesiol 2016;82:989-99



Syndrome post-arrêt cardiaque

REIN

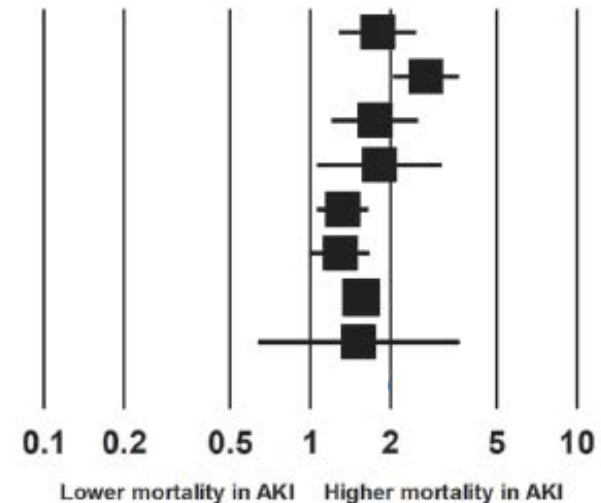
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IRA et mortalité



**Syndrome post-
arrêt cardiaque**

FOIE

Clinical paper

Hypoxic hepatitis after out-of-hospital cardiac arrest: Incidence, determinants and prognosis[☆]

B. Champigneulle^{a,b,*}, G. Geri^{a,b,d}, W. Bougouin^{a,b,d}, F. Dumas^{b,c,d}, M. Arnaout^{a,b}, L. Zafrani^a, F. Pène^{a,b}, J. Charpentier^a, J.P. Mira^{a,b}, A. Cariou^{a,b,d}

Resuscitation 2016;103:60-5

Syndrome post-arrêt cardiaque

FOIE

Hypoxic hepatitis after out-of-hospital cardiac arrest: Incidence, determinants and prognosis[☆]

632 ACEH

72 HH (11%)

Décès : 86%

Hépatite hypoxique

=

FDR décès en réa

OR 4.4 [1.7-11.2]

**Syndrome post-
arrêt cardiaque**

FOIE



Delignette MC et al.

Ann Intensive Care 2020 (S1):16

	Odds ratio	95% IC	<i>p</i>
Survenue de l'AC à domicile	3.52	1.87-6.71	<.001
Absence de RCP par un témoin	3.73	1.94-7.39	<.001
Etiologie non-cardiaque de l'AC	5.78	3.05-11.29	<.0001
Low-flow $\geq$ 20 min	8.84	4.44-18.78	<.0001
IHA à l'admission (TP < 50 %)	16.15	3.05-294.9	.008

**Syndrome post-
arrêt cardiaque**

POUMON

Cyclosporine A prevents cardiac arrest-induced acute respiratory failure: a post-hoc analysis of the CYRUS trial

Louis Kreitmann^{1,2}, Laurent Argaud^{1,2,3}, Michel Ovize^{2,3,4}, Martin Cour^{1,2,3*}  and For the CYRUS Study Group

Intensive Care Med 2020;46:1281-3

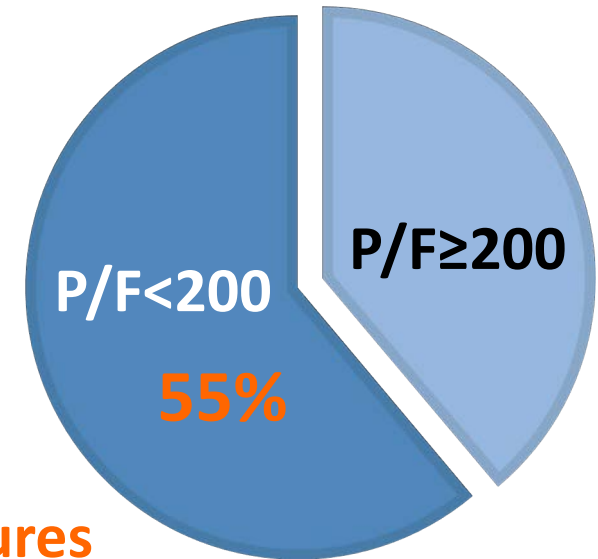
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Intensive Care Med 2020;46:1281-3



À 24 heures

**Syndrome post-
arrêt cardiaque**

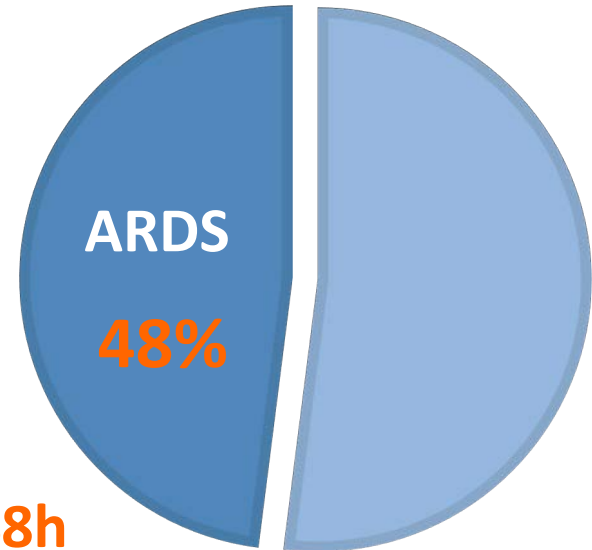
POUMON

Clinical paper

**The acute respiratory distress syndrome
after out-of-hospital cardiac arrest:
Incidence, risk factors, and outcomes**

Nicholas J. Johnson^{a,b,}, Ellen Caldwell^b, David J. Carlbom^b,
David F. Gaieski^c, Matthew E. Prekker^d, Thomas D. Rea^{e,f},
Michael Sayre^{a,g}, Catherine L. Hough^b*

Resuscitation 2019;35:37-44



Dans les 48h

Syndrome post-arrêt cardiaque

POUMON

Clinical paper

The acute respiratory distress syndrome after out-of-hospital cardiac arrest: Incidence, risk factors, and outcomes

Nicholas J. Johnson^{a,b,*}, Ellen Caldwell^b, David J. Carlbom^b,
David F. Gaieski^c, Matthew E. Prekker^d, Thomas D. Rea^{e,f},
Michael Sayre^{a,g}, Catherine L. Hough^b

Resuscitation 2019;35:37-44

SDRA

=

FDR décès Hôp.

OR 2.0 [1.5-2.9]

Syndrome post-arrêt cardiaque

INTESTIN

CATECHOLAMINE USE IS ASSOCIATED WITH ENTEROCYTE DAMAGE IN CRITICALLY ILL PATIENTS

Gaël Piton,^{*†} Benoit Cypriani,[‡] Jacques Regnard,^{§†} Cyrille Patry,^{*} Marc Puyraveau,^{||} and Gilles Capellier^{*†||}

Shock 2015

Variable of gastrointestinal dysfunction	+0 h
Intra abdominal pressure, mmHg	13 (10–18)
IAP ≥ 12 mmHg	32/51 (63)
APP, mmHg	68 (58–83)
APP < 60 mmHg	14/51 (27)
Citrulline, $\mu\text{mol L}^{-1}$	14.7 (8.8–27.9)
Citrulline < 20 $\mu\text{mol L}^{-1}$	41/60 (68)
I-FABP, pg mL^{-1}	291 (0–751)
I-FABP > 100 pg mL^{-1}	37/60 (62)

**I-FABP augmenté
=
62% patients**

**Syndrome post-
arrêt cardiaque**

**Défaillance
multi-viscérale**



Clinical paper

SOFA score to assess the severity of the post-cardiac arrest syndrome[☆]

Martin Cour^{a,b,c}, Didier Bresson^{a,b}, Romain Hernu^{a,b}, Laurent Argaud^{a,b,c,*}

Cour M et al. *Resuscitation* 2016;102:110-5

Syndrome post-arrêt cardiaque

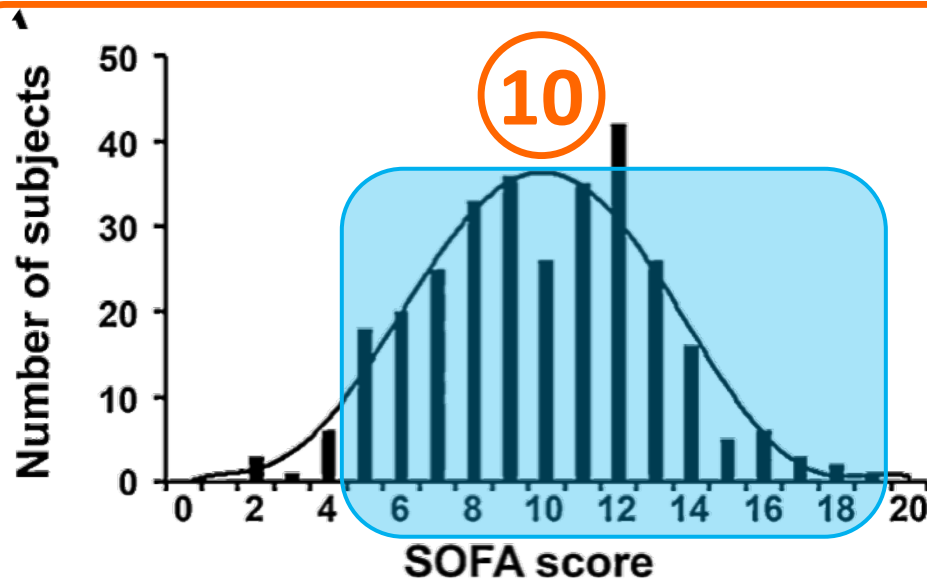
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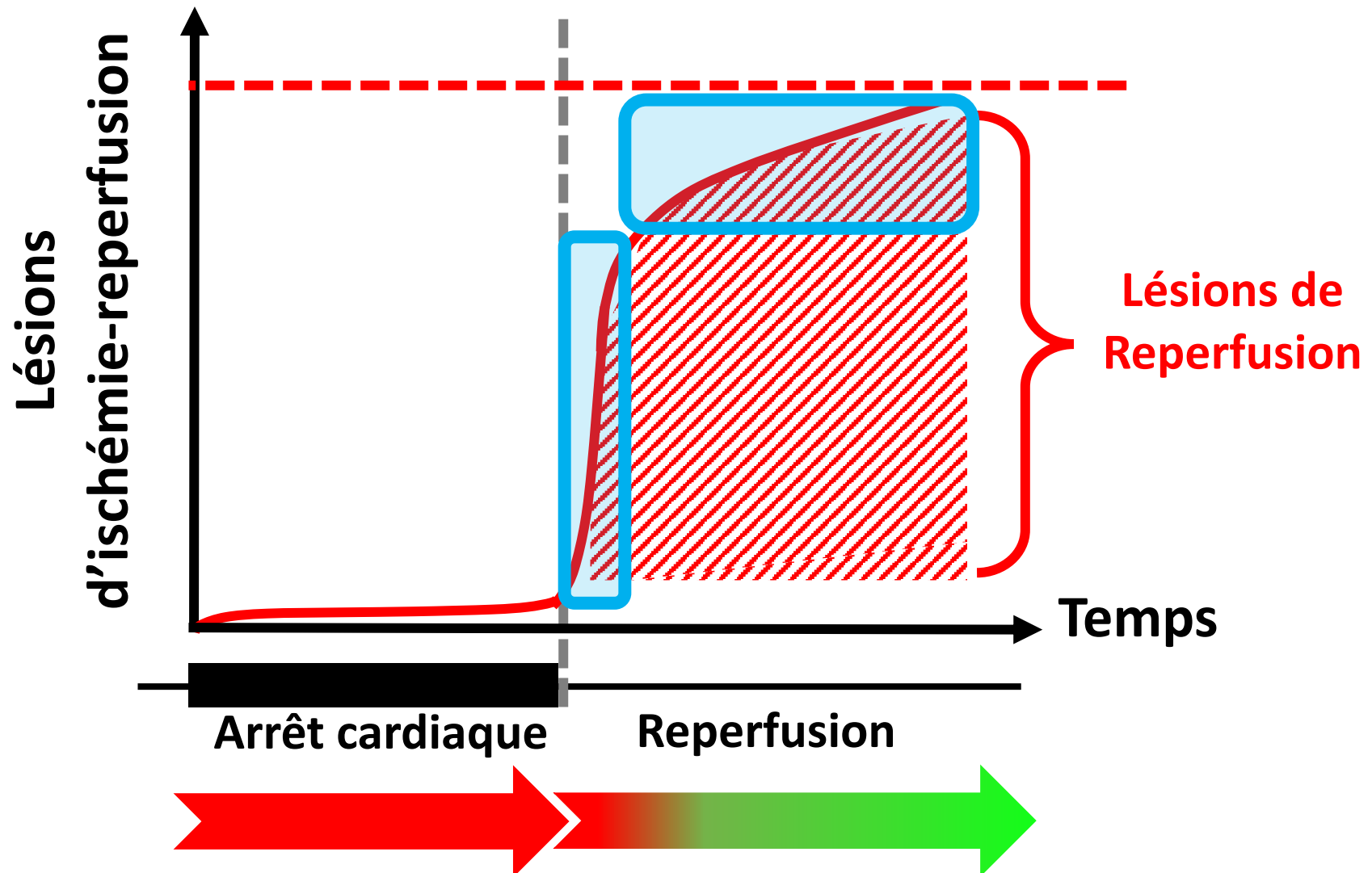


Score SOFA

=

FDR décès J28

OR 1.17 [1.01-1.35]



SYNDROME POST-ARRÊT CARDIAQUE

=

Dysfonction myocardique

+

Défaillance neurologique

+

Réponse systémique à l'ischémie-reperfusion

+

Persistance de la pathologie causale

RECHERCHER ET TRAITER LA CAUSE

THROMBUS (IDM/EP)

HYPOXIE

TAMPONNADE

HYPOVOLEMIE

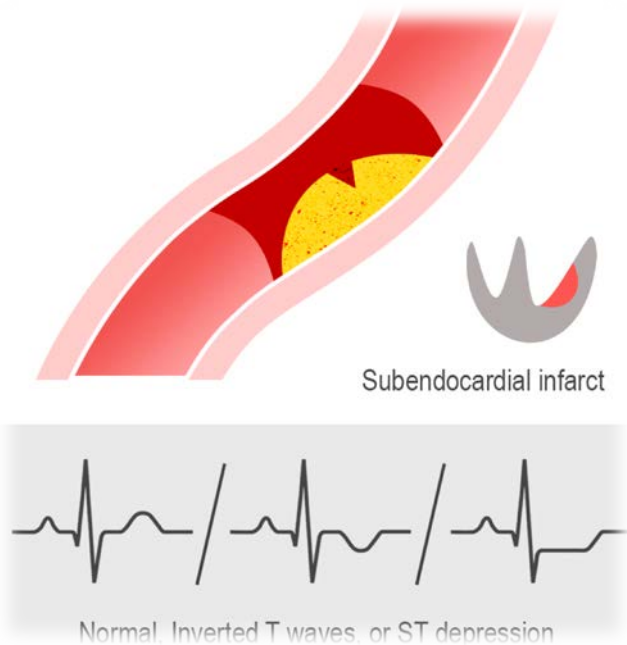
TOXIQUE

HYPERKALIEMIE

PNEUMOTHORAX

HYPOTHERMIE

Arrêt cardiaque sans élévation du segment ST ?



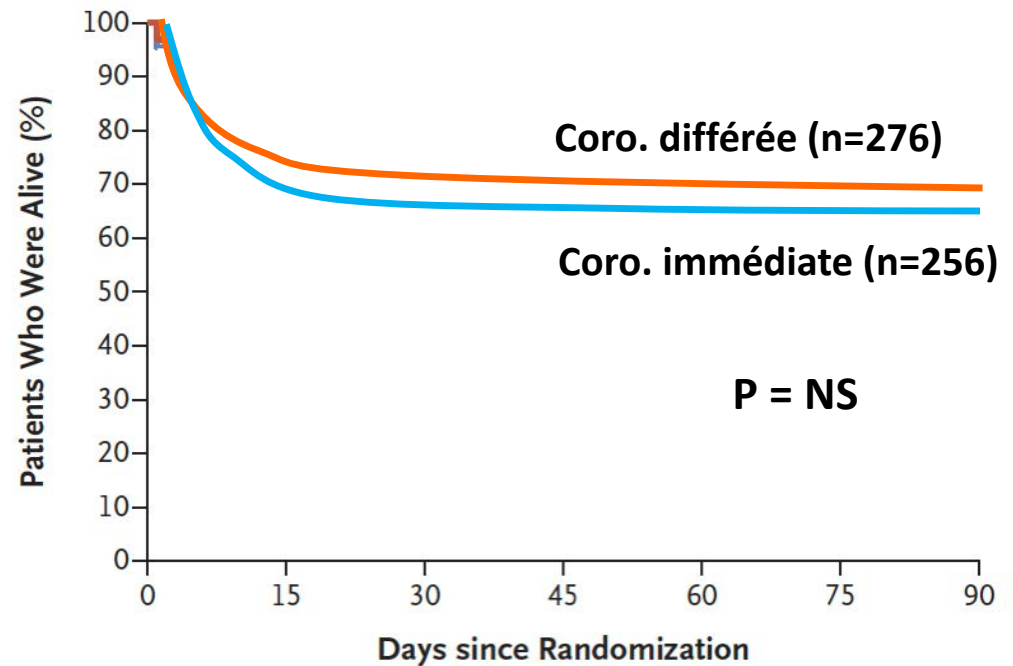
The NEW ENGLAND JOURNAL *of* MEDICINE

ESTABLISHED IN 1812

APRIL 11, 2019

VOL. 380 NO. 15

Coronary Angiography after Cardiac Arrest without ST-Segment Elevation



Choc post-AC

Cardiogénique

ANGIOPLASTIE

DOBUTAMINE

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION



Successful Cardiopulmonary

Vasoplégique

“Sepsis-Like” syndrome

Adrie C et al. *Circulation* 2002;106:562-8

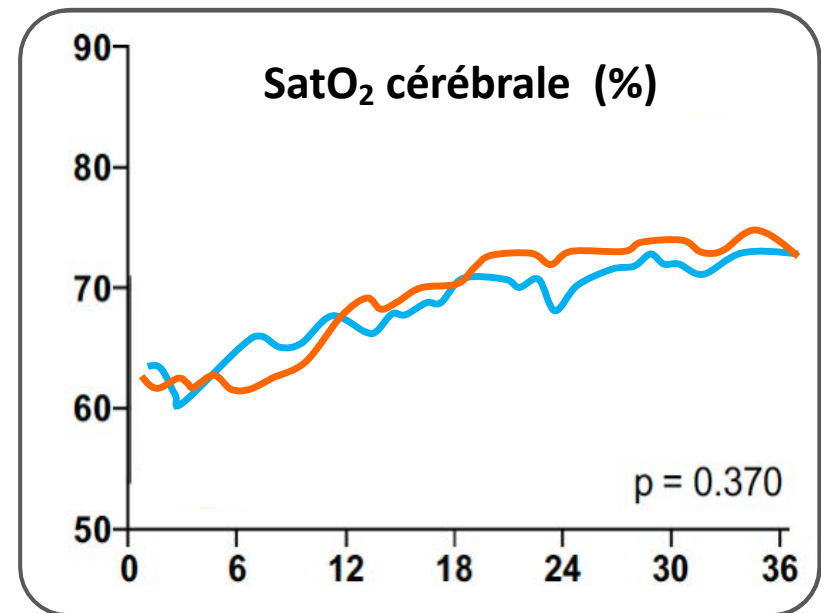
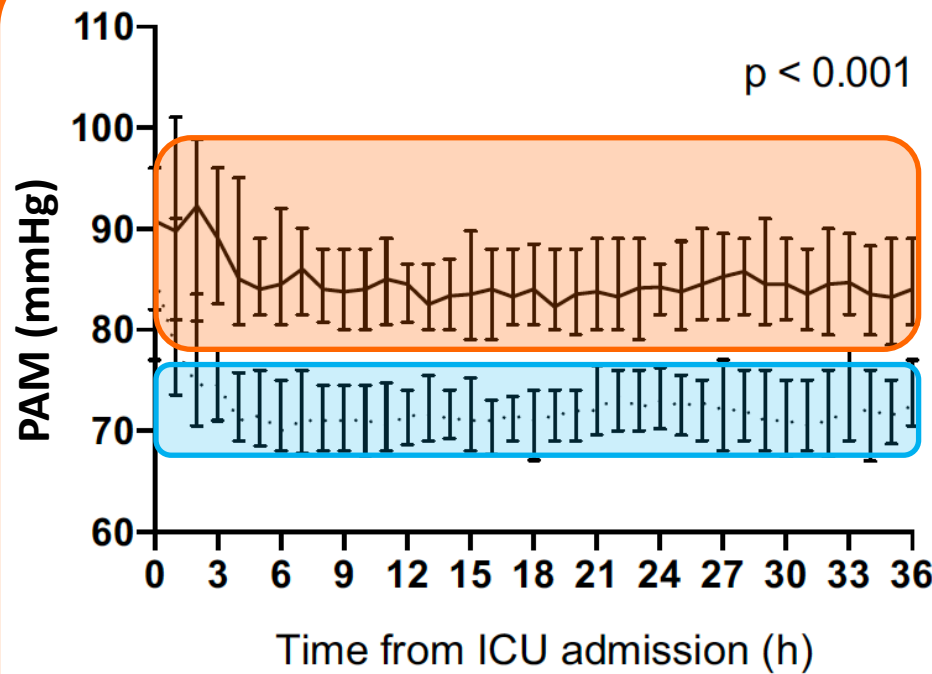
REEMPLISSAGE

NORADRENALINE

Choc cardio-circulatoire post-AC



Quel objectif de PAM ?



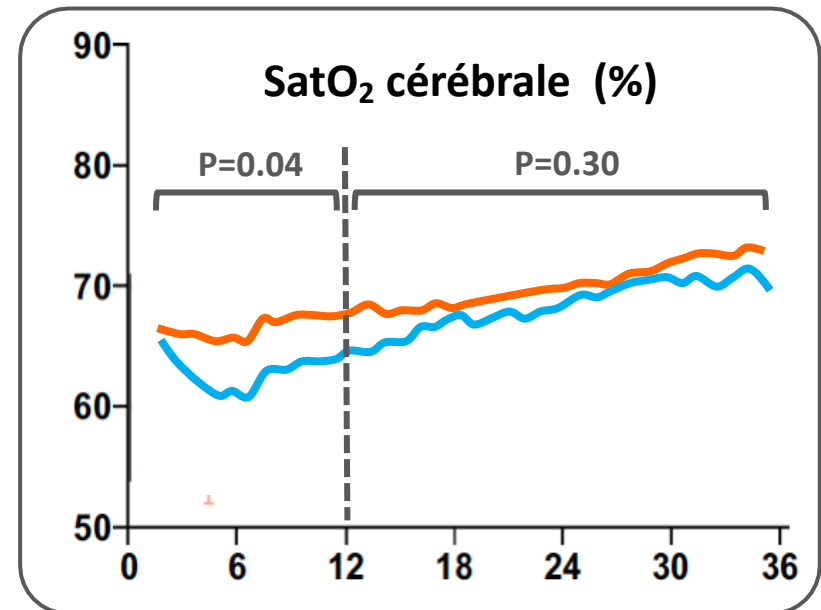
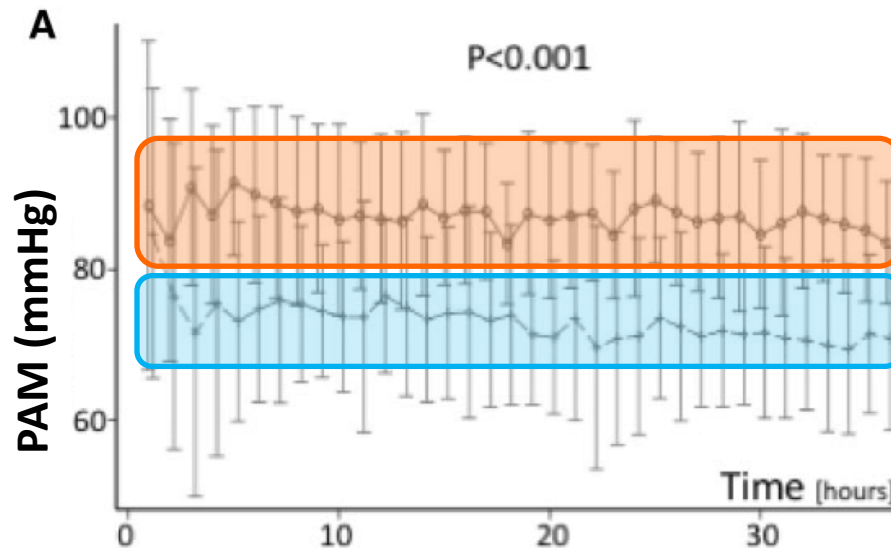
Jakkula P et al. *Intensive Care Med* 2018;44:2091-101

Choc cardio-circulatoire post-AC

?

Quel objectif de PAM ?

PAM 65 vs. 85-100 mmHg (+SvO₂)



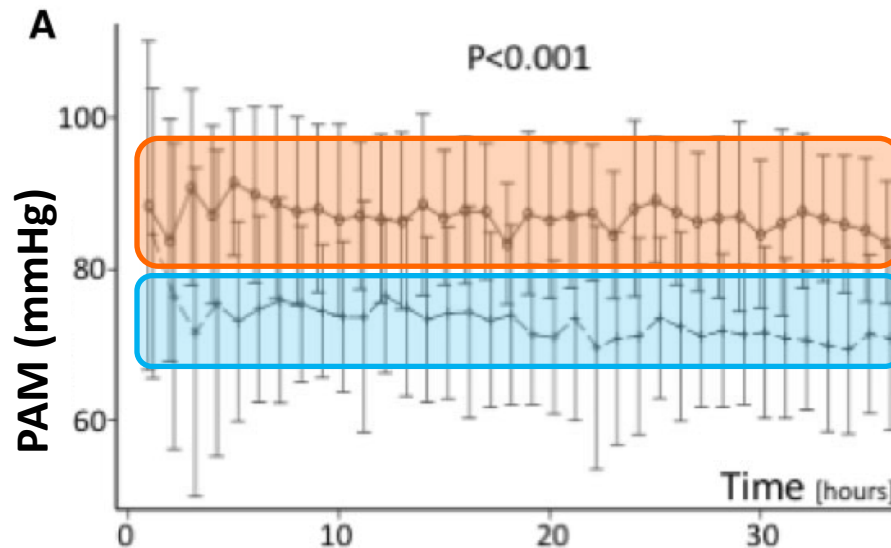
Ameloot K et al. *Eur Heart J* 2019; 40:1804-14

Choc cardio-circulatoire post-AC

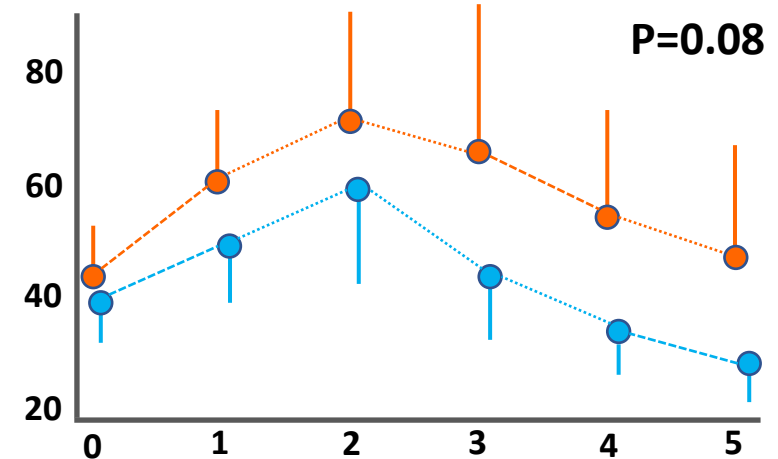


Quel objectif de PAM ?

PAM 65 vs. 85-100 mmHg (+SvO₂)



Neuron Specific Enolase



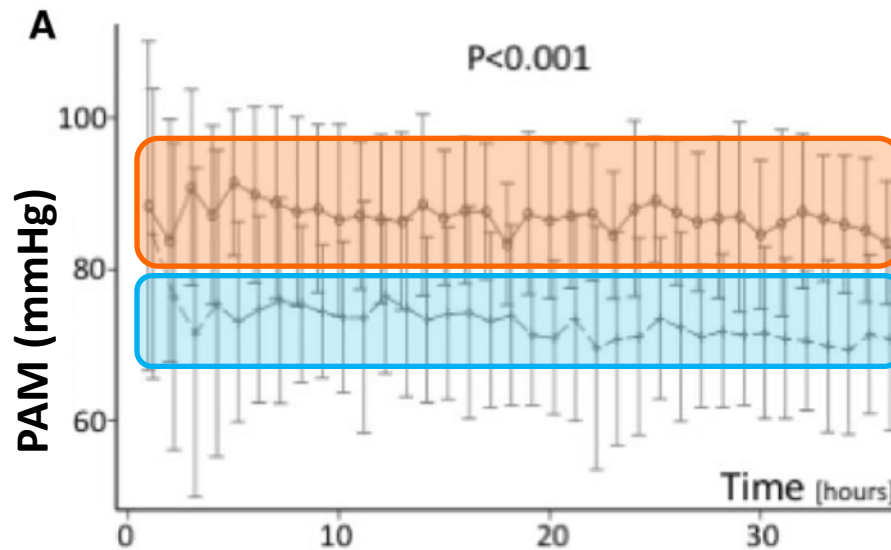
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Choc cardio-circulatoire post-AC

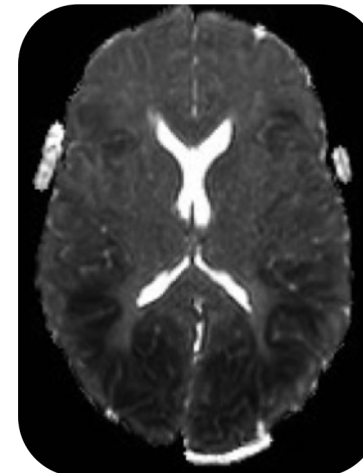
?

Quel objectif de PAM ?

PAM 65 vs. 85-100 mmHg (+SvO₂)



% voxels avec ADC < 650



16%

VS.

12%

P=0.09

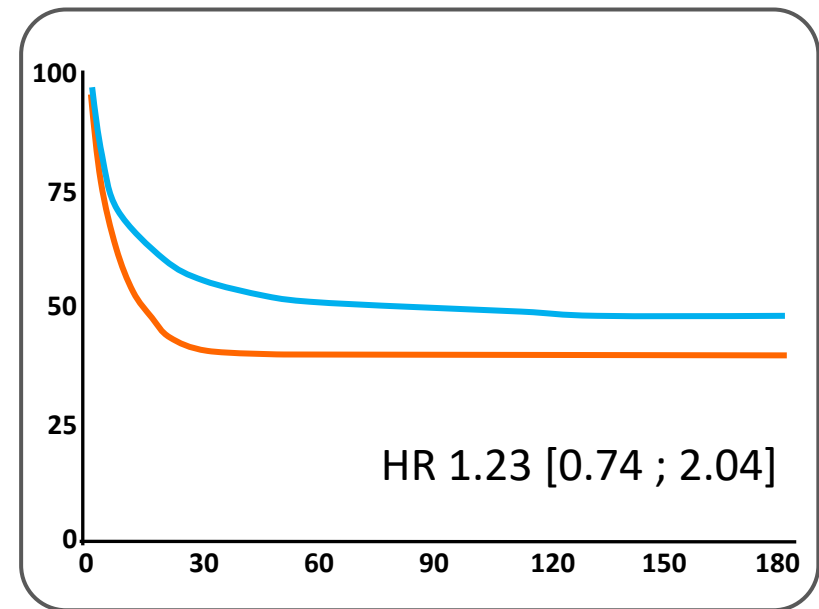
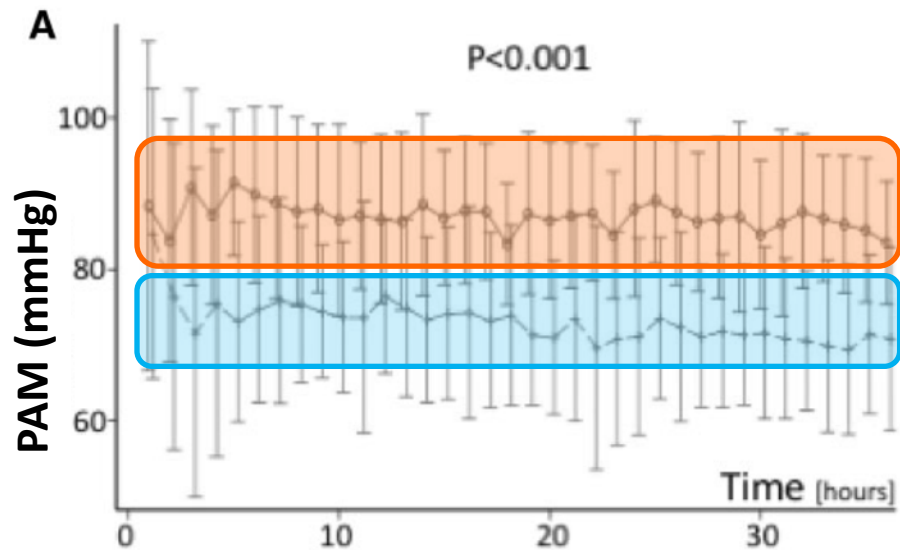
Ameloot K et al. *Eur Heart J* 2019; 40:1804-14

Choc cardio-circulatoire post-AC

?

Quel objectif de PAM ?

PAM 65 vs. 85-100 mmHg (+SvO₂)



Ameloot K et al. *Eur Heart J* 2019; 40:1804-14

**Choc cardio-
circulatoire post-AC**



**Quel objectif de
PAM ?**

The Burden of Brain Hypoxia and Optimal Mean Arterial Pressure in Patients With Hypoxic Ischemic Brain Injury After Cardiac Arrest*

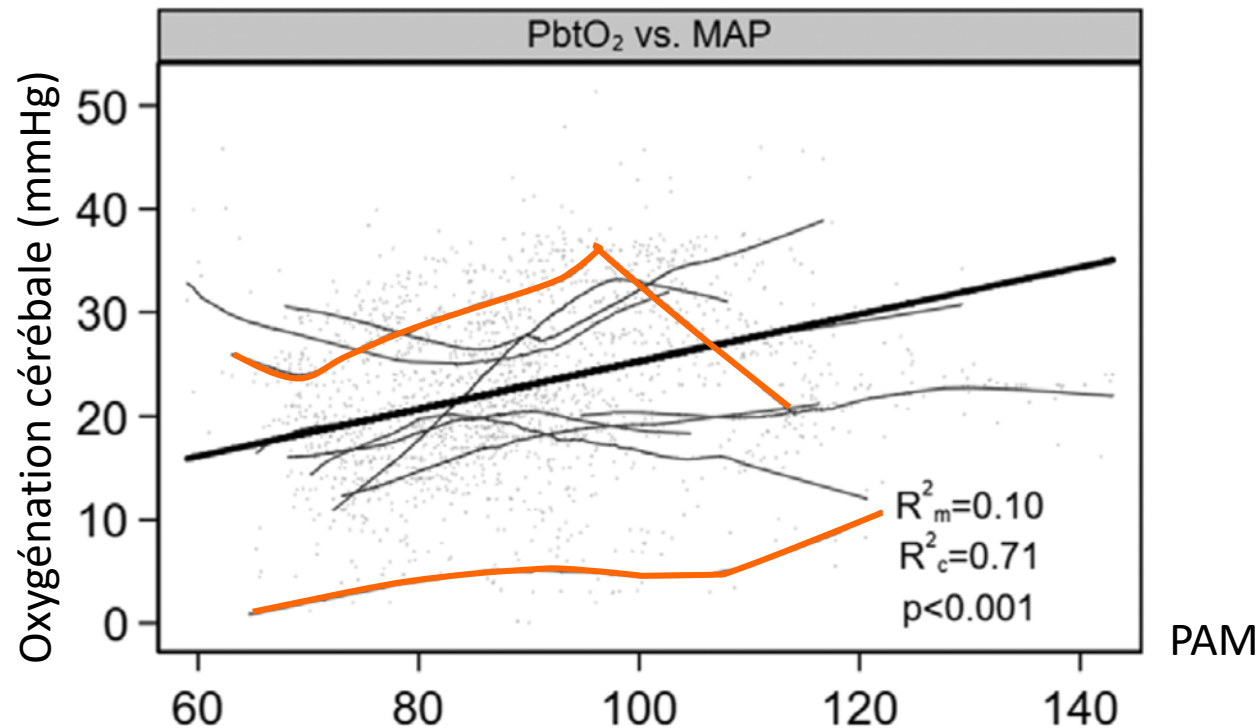
Mypinder S. Sekhon, MD¹; Peter Gooderham, MD²; David K. Menon, MD, PhD³;
Penelope M. A. Brasher, PhD⁴; Denise Foster, RN¹; Danilo Cardim, PhD⁵; Marek Czosnyka, PhD³;
Peter Smielewski, PhD³; Arun K. Gupta, MBBS, PhD³; Philip N. Ainslie, PhD⁶;
Donald E. G. Griesdale, MD, MPH^{1,4,5}

Sekhon M et al. *Crit Care Med* 2019; 47:960-9

Choc cardio-circulatoire post-AC

?

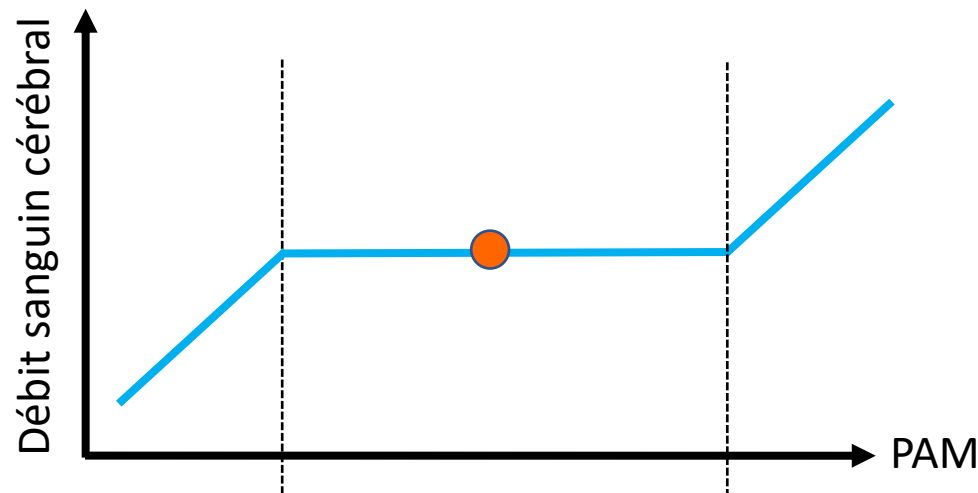
Quel objectif de PAM ?



Choc cardio-circulatoire post-AC

?

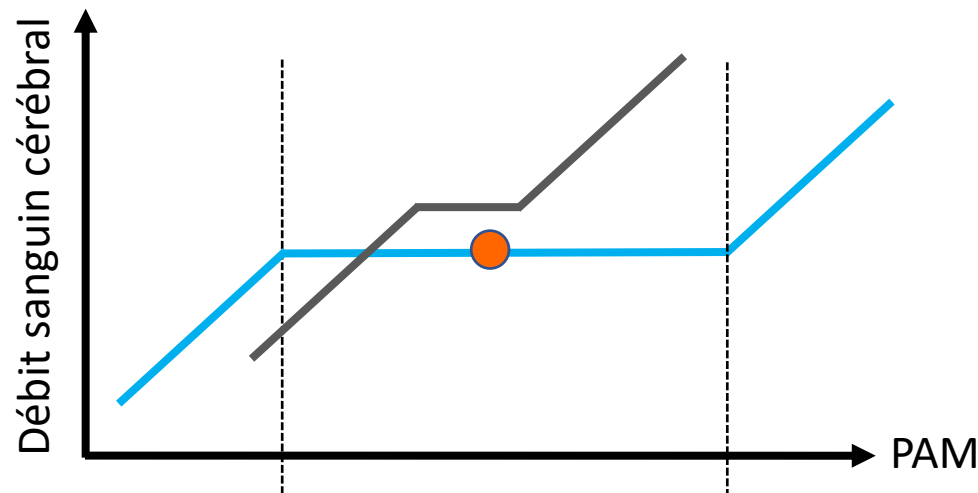
Quel objectif de PAM ?



Choc cardio-circulatoire post-AC

?

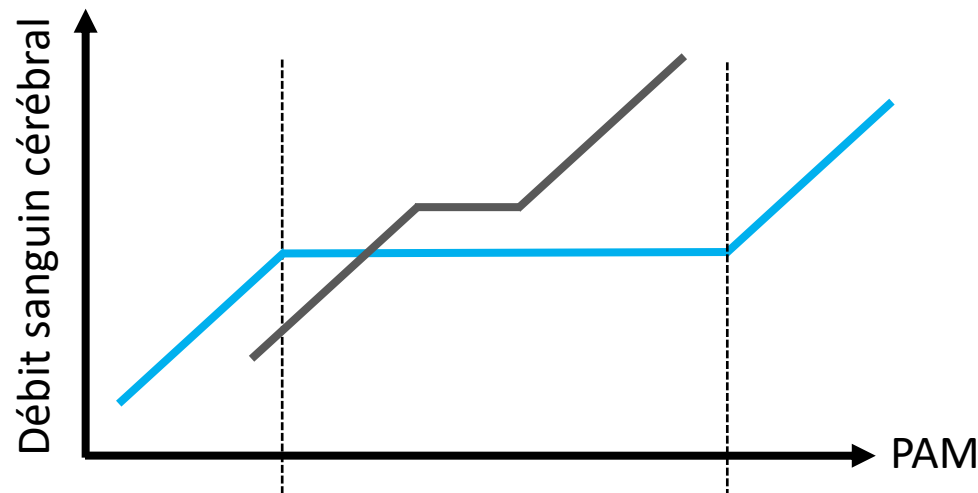
Quel objectif de PAM ?



Choc cardio-circulatoire post-AC

?

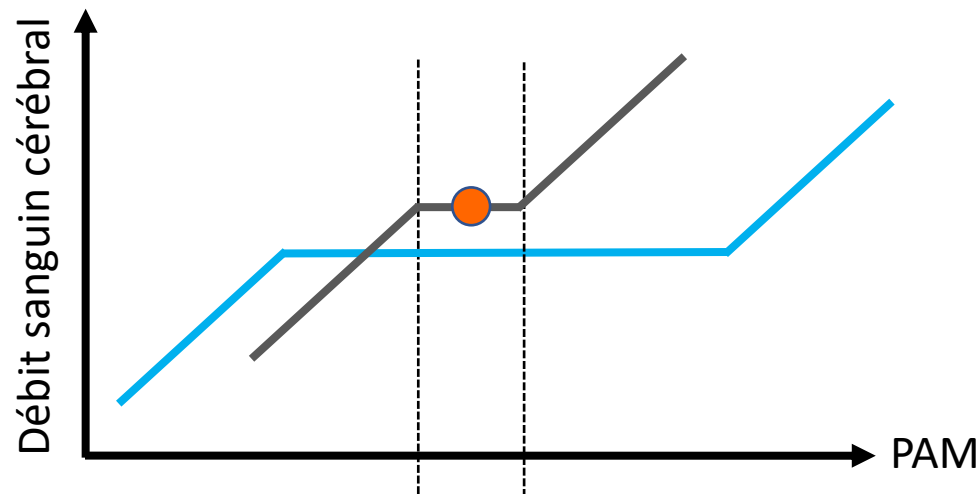
Quel objectif de PAM ?



Choc cardio-circulatoire post-AC

?

Quel objectif de PAM ?



Choc cardio-
circulatoire post-AC

?

Quel objectif de
PAM ?



PAM > 65 mmHg

PAM pour diurèse > 0.5 ml/kg/h

Noradrénaline

Nolan JP et al. *Intensive Care Med* 2021;47:369-421

Choc cardio-circulatoire post-AC



Traitements adjuvants ?

Insuffisance surrénale relative : **42%** (21/50)

Temps avant résolution du choc :

Groupe traité (n=25) : **55** (30-59) heures

Groupe contrôle (n=25) : **49** (25-71) heures

Donnino MW et al. *Crit Care* 2016;20:82

**Choc cardio-
circulatoire post-AC**

?

**Assistance
circulatoire ?**

94 patients
2/3 post-IDM

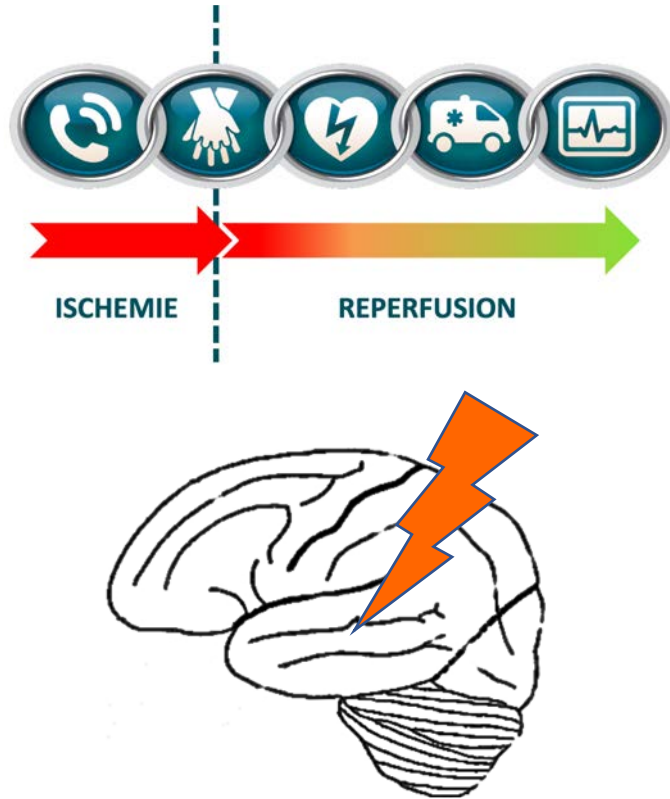
Survie : 28%

Intensive Care Med 2016

52 patients
2/3 post-IDM

Survie : 25% (vs. 21%)

Resuscitation 2017



Stress oxydant

Surcharge calcique

Excito-toxicité glutamate

Lésions mitochondriales

Inflammation



OXYGENATION

ORIGINAL

Conservative oxygen therapy for mechanically ventilated adults with suspected hypoxic ischaemic encephalopathy



Young et al. *Intensive Care Med* 2020;46:2411-22

	Conservative oxygen (n = 87)	Usual oxygen (n = 79)	Estimate ^a (95% CI) Odds ratio	
	(SpO ₂ 90-97%)	(SpO ₂ 90-100%)	Unadjusted	P value
Unfavourable neurological outcome at day 180—n/N (%)	43/78 (55.1%) 55%	49/72 (68.1%) 68%	0.58 (0.3–1.12)	0.10 P=NS

The EXACT protocol: a multi-centre, single-blind, randomised, parallel-group, controlled trial to determine whether early oxygen titration improves survival to hospital discharge in adult OHCA patients.



Bray JE et al. *Resuscitation* 2019;139:208-13

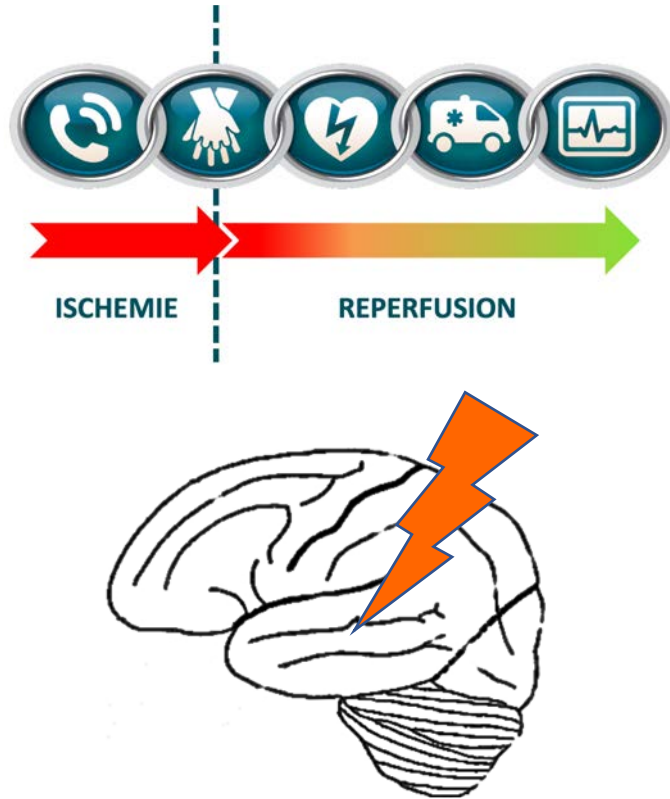
Avant
admission réa

1416 ACEH

SpO₂ 92-94%

SpO₂ 98-100%

CJP = sortie vivant de l'Hôpital



Stress oxydant

Surcharge calcique

Excito-toxicité glutamate

Perte autorégulation

Inflammation



Hypercapnie permissive

Ventilation / CO₂



ELSEVIER

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation



Clinical paper

Targeted therapeutic mild hypercapnia after cardiac arrest: A phase II multi-centre randomised controlled trial (the CCC trial)[☆]

Eastwood GM et al. *Resuscitation* 2016;104:83-90

NSE ?

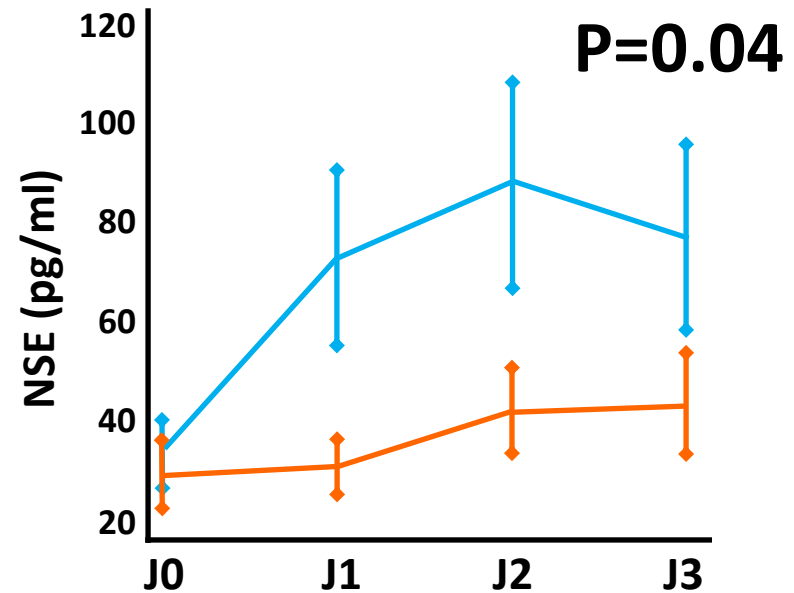
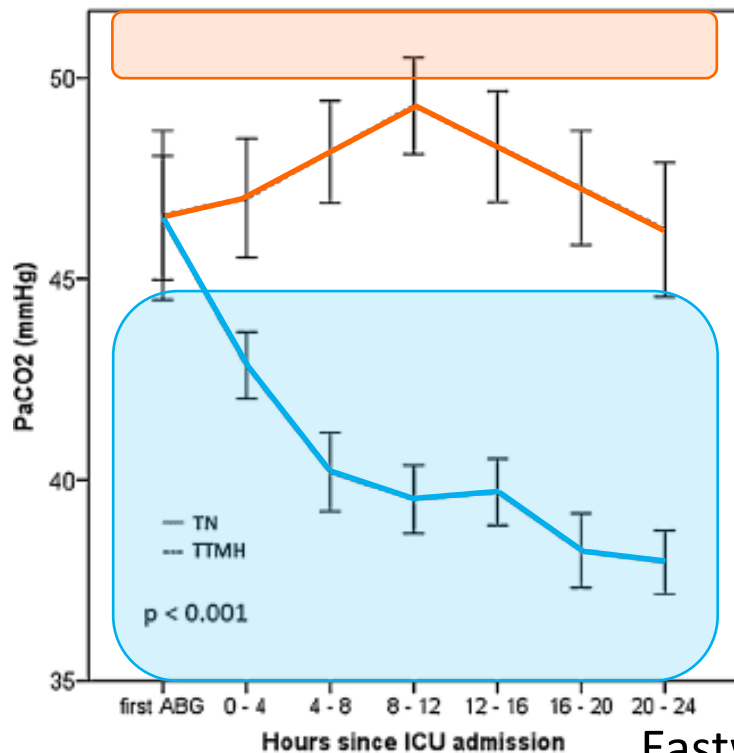
86 ACEH

CO₂ 35-45 (41)

CO₂ 50-55 (45)

Ventilation / CO₂

Targeted therapeutic mild hypercapnia after cardiac arrest: A phase II multi-centre randomised controlled trial (the CCC trial)☆



Eastwood GM et al. *Resuscitation* 2016;104:83-90

Ventilation / CO₂



1700 ACEH



15 pays



56 sites



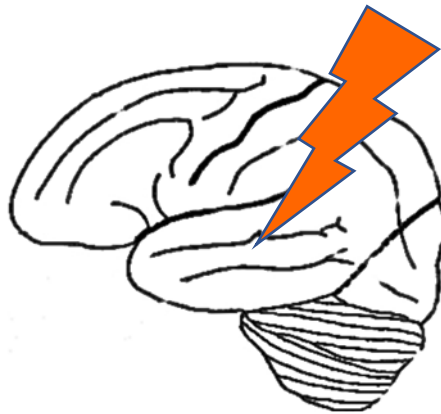
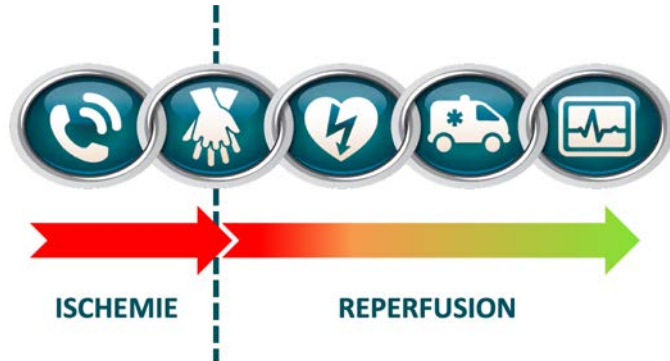
Recrutement
complet

CO₂ 35-45 mmHg

VS.

CO₂ 50-55 mmHg

CJP = *Glasgow Outcome Scale Extended* à 6 mois



Stress oxydant

Surcharge calcique

Excito-toxicité glutamate

Lésions mitochondriales

Inflammation



Gestion ciblée de la température

Hyperthermia After Cardiac Arrest Is Associated With an Unfavorable Neurologic Outcome

Association significative mortalité / hyperthermie
OR 2.3 par °C > 37°C

Zeiner A et al. *Arch Int Med* 2001;161:2007-12

HACA Study Group. *New Engl J Med* 2002



Bernard SA et al. *New Engl J Med* 2002

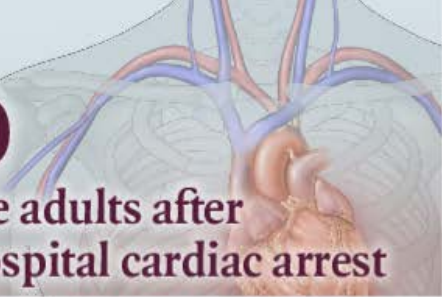


33°C versus < 37,9°C

1850 patients
14 pays



Dankiewicz et al. *New Engl J Med* 2021;384:2283-94

 1850 Comatose adults after out-of-hospital cardiac arrest	Hypothermia (target body temperature, 33°C) N=925 	Normothermia (target body temperature, $\leq 37.5^{\circ}\text{C}$) N=925 
Death from any cause at 6 mo	50% RR, 1.04; 95% CI, 0.94 to 1.14; P=0.37	48%
Modified Rankin scale score ≥ 4 at 6 mo	55% RR, 1.00; 95% CI, 0.92 to 1.09	55%
Arrhythmia with hemodynamic compromise	24%	17%



Temp $\leq 37.5^{\circ}\text{C}$, $\geq 72\text{h}$



Soar J et al. ILCOR Advance Life Support Task Force 2021 (<http://ilcor.org>)

Réponse systémique à l'I/R

Effect of Cyclosporine in Nonshockable Out-of-Hospital Cardiac Arrest
The CYRUS Randomized Clinical Trial

JAMA Cardiol 2016

Early High-Dose Erythropoietin Therapy After Out-of-Hospital Cardiac Arrest

A Multicenter, Randomized Controlled Trial

Am J Coll Cardiol 2016

Neuroprotective Effects of the Glucagon-Like Peptide-1 Analog Exenatide After Out-of-Hospital Cardiac Arrest

Circulation 2016

Hemodynamic efficiency of hemodialysis treatment with high cut-off membrane during the early period of post-resuscitation shock: the HYPERDIA trial

Resuscitation 2019

"Endothelial Dysfunction in Resuscitated Cardiac Arrest (ENDORCA): Safety and efficacy of low-dose iloprost, prostacyclin analogue, in addition to standard therapy, as compared to standard therapy alone, in post-cardiac-arrest-syndrome patients"

Am Heart J 2020

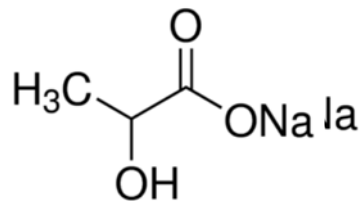
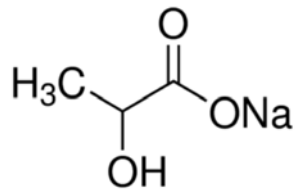
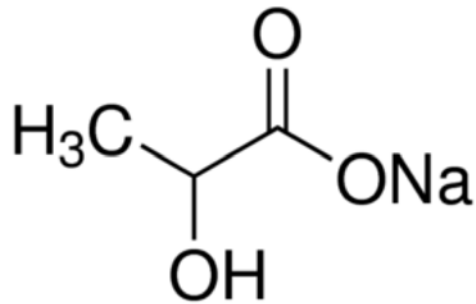
Effect of Out-of-Hospital Sodium Nitrite on Survival to Hospital Admission After Cardiac Arrest

A Randomized Clinical Trial

JAMA 2021



Et après ?



Molar Sodium Lactate Attenuates the Severity of Postcardiac Arrest Syndrome: A Preclinical Study

Stevic N et al. Crit Care Med 2021

Review

Brain Protection after Anoxic Brain Injury: Is Lactate Supplementation Helpful?

Annoni F et al. Cells 2021

Hypertonic Lactate After Cardiac Arrest (LATTE)

 U.S. National Library of Medicine

ClinicalTrials.gov

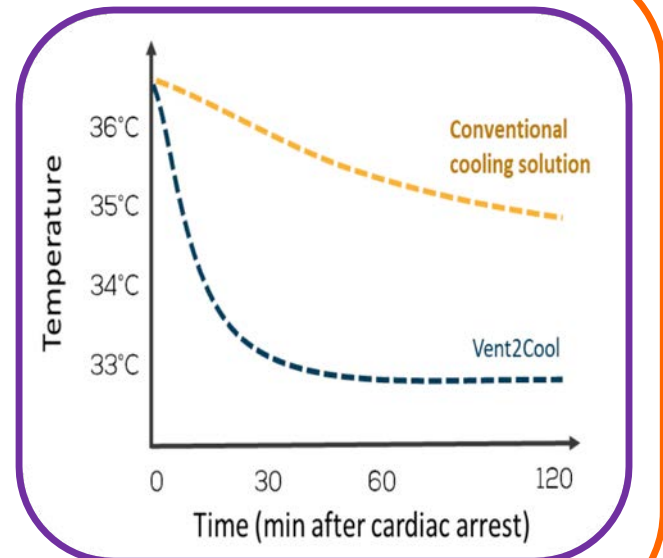
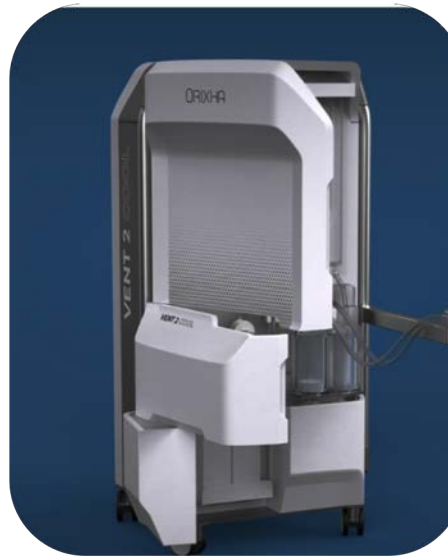
Annoni F, Taccone FS



Et après ?



TECHNOLOGIE DE VENTILATION LIQUIDE POUR AMÉLIORER LA PRISE EN CHARGE DE L'ARRÊT CARDIAQUE : L'ENVA VALIDE LE PROTOTYPE VENT2COOL DE LA START-UP ORIXHA





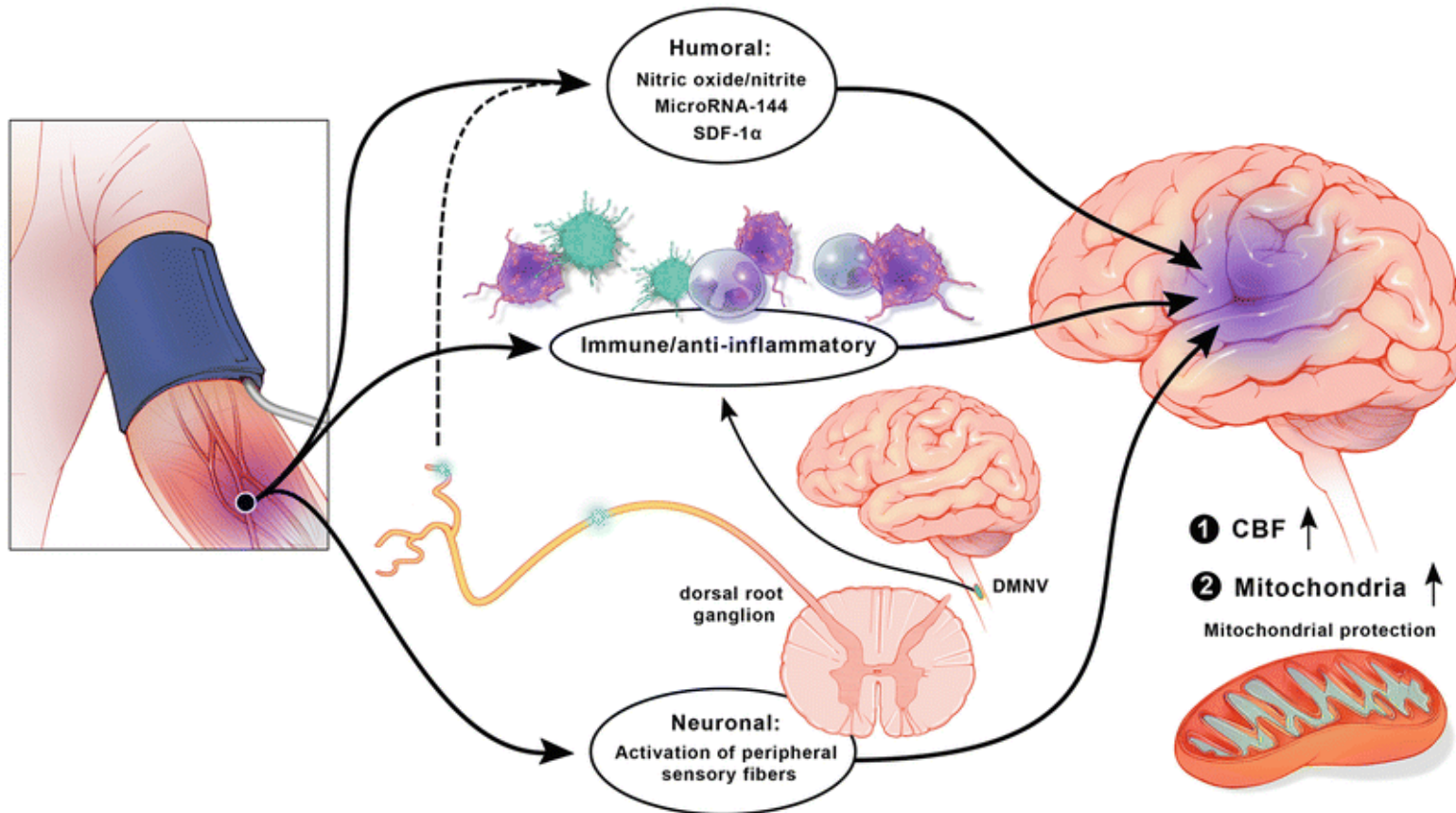
Et après ?

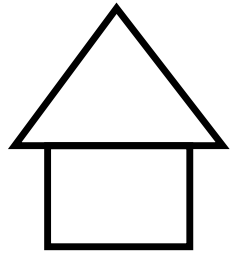


RECO-OHCA

*Remote ischemic conditioning
in out-of-hospital cardiac arrest*

PHRC-I 2019





**TAKE HOME
MESSAGE**

**Traitement
de la cause**



Normoxie

Normocapnie

PAM > 65 mmHg

Normothermie

Merci pour votre attention !