Year in Review: Cardiac Arrest 2019

neumar@umich.edu

Robert W. Neumar, MD, PhD
Professor and Chair,
Department of Emergency Medicine
University of Michigan
Ann Arbor, Michigan, USA

@neumar_robert

Resuscitation Science Symposium 2019

Nov. 16–17, 2019

The Philadelphia 201 Hotel | 201 N. 17th St., Philadelphia, Pennsylvania

Disclosures

- Co-Chair: International Liaison Committee on Resuscitation (ILCOR)
- Member: ILCOR ALS Task Force
- President and Board Chair, SaveMiHeart
- NIH and AHA Research Funding
- PhysioControl/Stryker: Equipment support for research

Year in Review: Cardiac Arrest 2019

Included

Original research published since ReSS 2018

Excluded

- Systematic reviews
- Meta-analyses
- Practice guidelines

Year in Review: Cardiac Arrest 2019

CPR

- Ventilation

Post-Cardiac Arrest

- Ventilation/oxygenation targets
- Blood pressure targets
- Targeted temperature management (TTM)
- Coronary angiography
- Antibiotics
- Neuroprognostication

Pediatric Critical Care

Ventilation Rates and Pediatric In-Hospital Cardiac Arrest Survival Outcomes*

Robert M. Sutton, MD, MSCE[1]; Ron W. Reeder, PhD[2]; William P. Landis, BSE[1]; Kathleen L. Meert, MD[3]; Andrew R. Yates, MD[4]; Ryan W. Morgan, MD, MTR[1]; John T. Berger, MD[5]; Christopher J. Newth, MD, FRACP[6]; Joseph A. Carcillo, MD[7]; Patrick S. McQuillen, MD[8]; Rick E. Harrison, MD[9]; Frank W. Moler, MD[10]; Murray M. Pollack, MD[5,11]; Todd C. Carpenter, MD[12]; Daniel A. Notterman, MD[13]; Richard Holubkov, PhD[2]; J. Michael Dean, MD[2]; Vinay M. Nadkarni, MD, MS[1]; Robert A. Berg, MD[1]; for the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Collaborative Pediatric Critical Care Research Network (CPCCRN)

Sutton Ped Crit Care 2019

Ventilation Rates and Pediatric IHCA Outcomes

Sutton Ped Crit Care 2019

Design: Prospective, multicenter observational study

Setting: Pediatric and pediatric cardiac ICUs of the Collaborative Pediatric Critical Care Research Network.

Population: 47 Intubated children (> 37 week <19 yrs) who received at least 1 minute of CPR

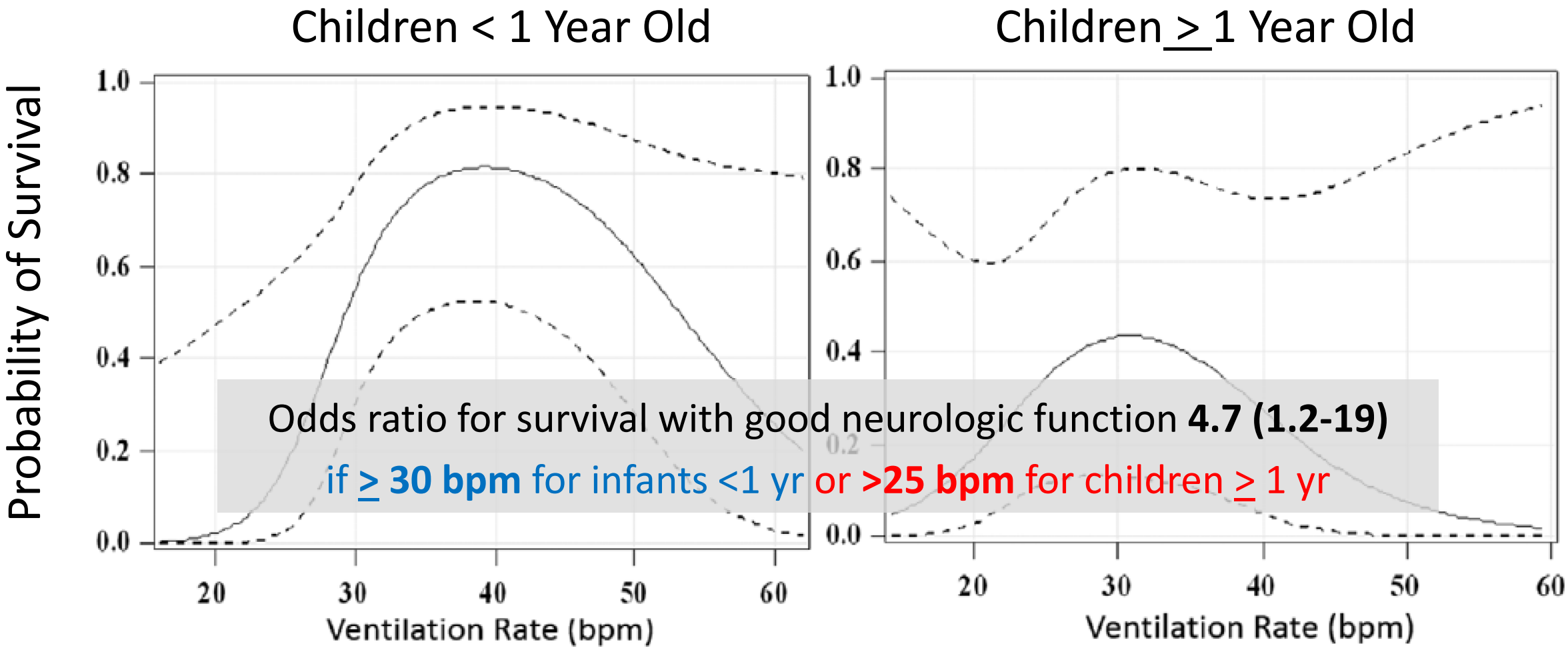
Variables Studied: Ventilation rate and arterial diastolic pressure

Outcome: Survival to hospital discharge

Ventilation Rates and Pediatric IHCA Outcomes

Sutton Ped Crit Care 2019

Median ventilation rate was 30 breaths/min (IQR 24–36)



Intensive Care Med (2018) 44:2112–2121
https://doi.org/10.1007/s00134-018-5453-9

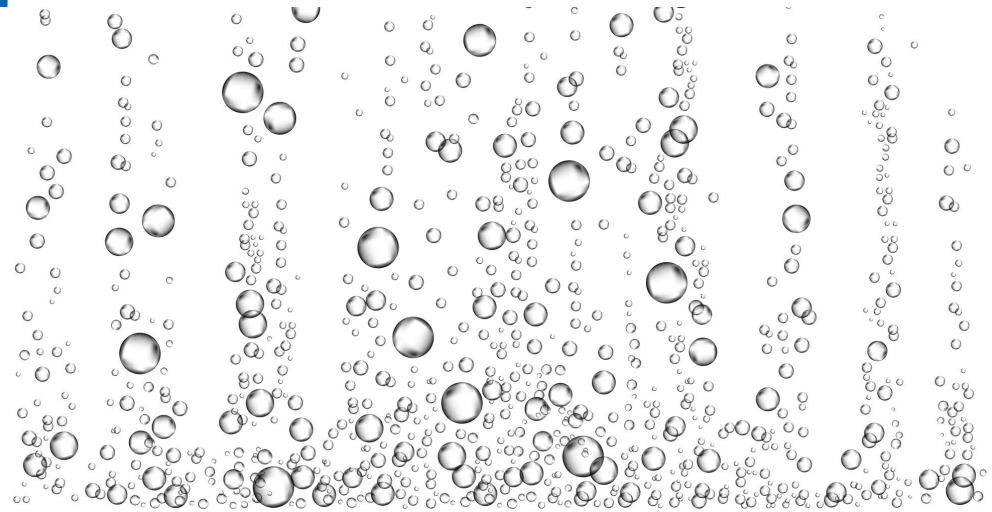
COMACARE Study

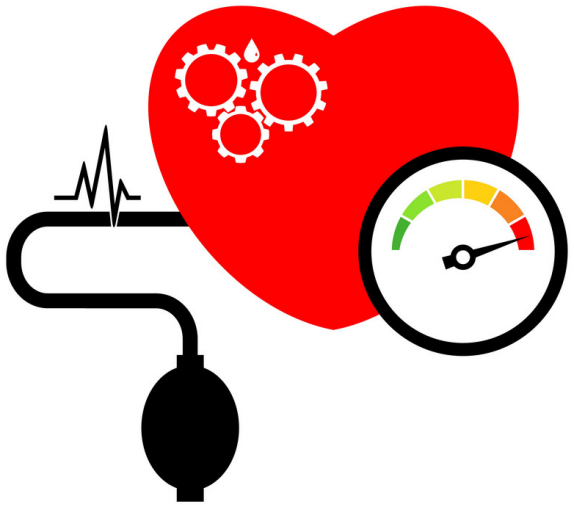
ORIGINAL

Targeting two different levels of both arterial carbon dioxide and arterial oxygen after cardiac arrest and resuscitation: a randomised pilot trial

Jakkula ICM 2018

Pekka Jakkula[1*], Matti Reinikainen[2], Johanna Hästbacka[1], Pekka Loisa[3], Marjaana Tiainen[5], Ville Pettilä[1], Jussi Toppila[6], Marika Lähde[4], Minna Bäcklund[1], Marjatta Okkonen[1], Stepani Bendel[7], Thomas Birkelund[8], Anni Pulkkinen[9], Jonna Heinonen[1], Tuukka Tikka[1], Markus B. Skrifvars[1,10] and COMACARE study group





ORIGINAL

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

Pekka Jakkula[1*], Ville Pettilä[1], Markus B. Skrifvars[1,2], Johanna Hästbacka[1], Pekka Loisa[3], Marjaana Tiainen[4], Erika Wilkman[1], Jussi Toppila[5], Talvikki Koskue[1], Stepani Bendel[6], Thomas Birkelund[7], Raili Laru-Sompa[8], Miia Valkonen[1], Matti Reinikainen[9] and COMACARE study group

Jakkula ICM 2018

COMACARE Study

Jakkula ICM 2018

Design: Prospective, randomized 2^3 factorial design multicenter clinical trial

Setting: Adult ICUs of the COMACARE Research Network

Subjects: 123 unconscious intubated post-arrest patients with witnessed VF/VT as initial rhythm

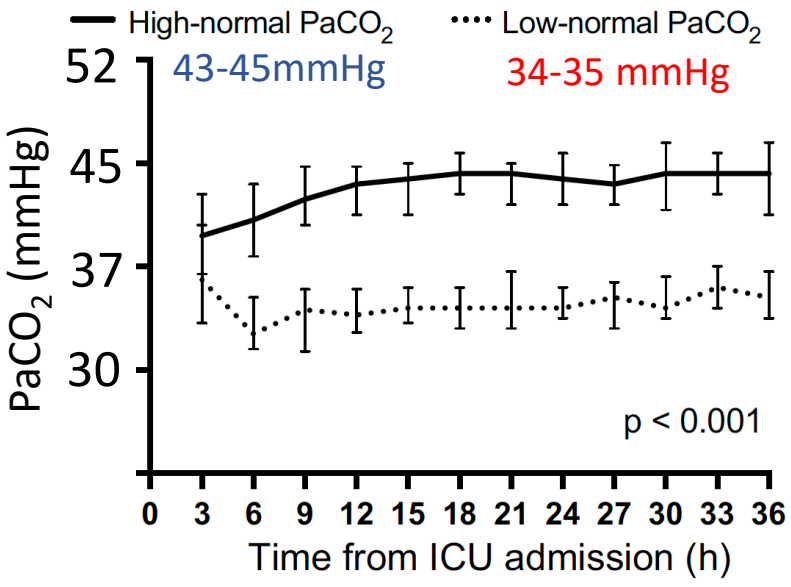
Intervention: Targeted $PaCO_2$, PaO_2, and MAP x 36 hours

Primary Outcome: Neuron specific enolase at 48 hours

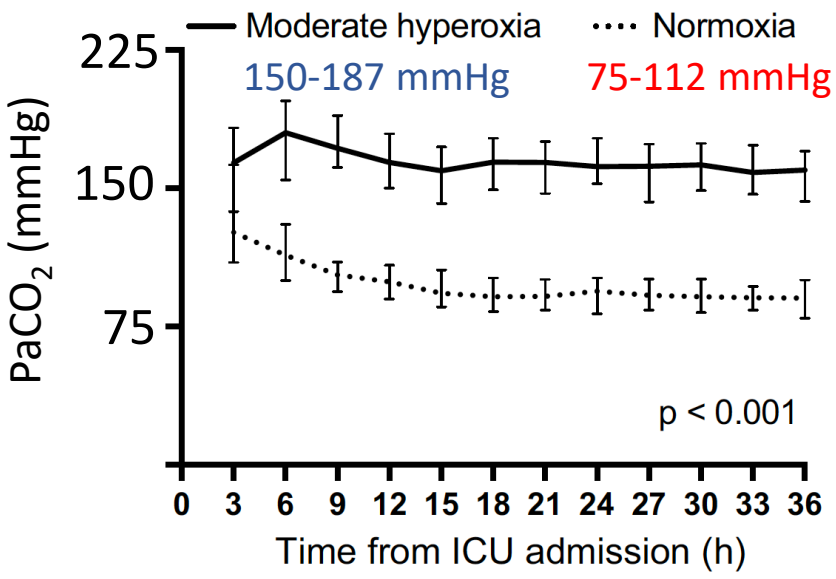
Secondary Outcome: Survival with good neurologic function (CPC 1-2 at 6 months)

COMACARE Study

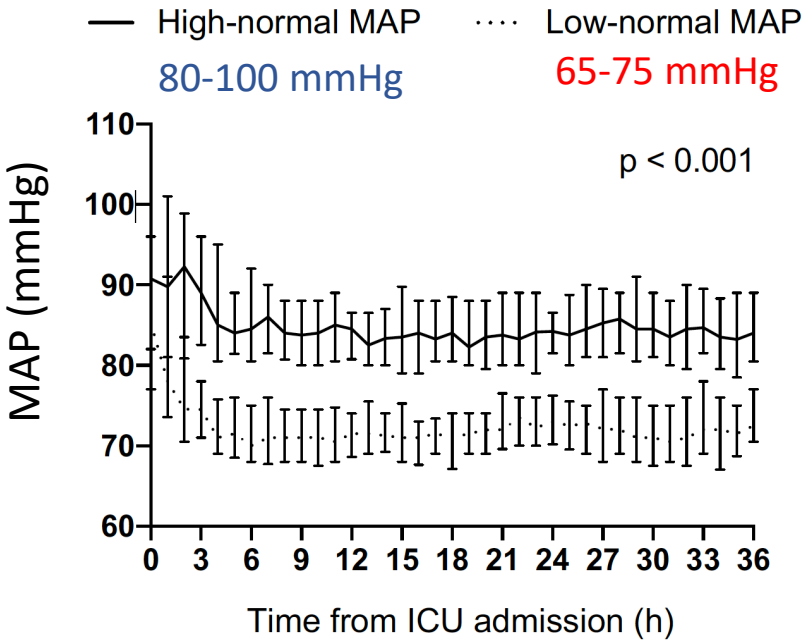
Jakkula ICM 2018



$PaCO_2$



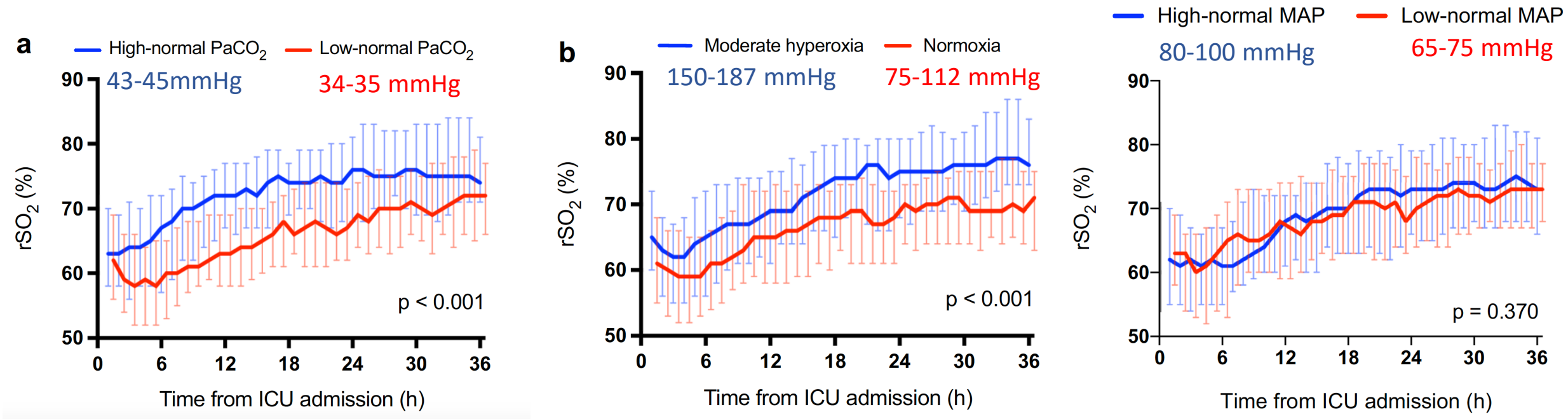
PaO_2



MAP

COMACARE Study

Jakkula ICM 2018

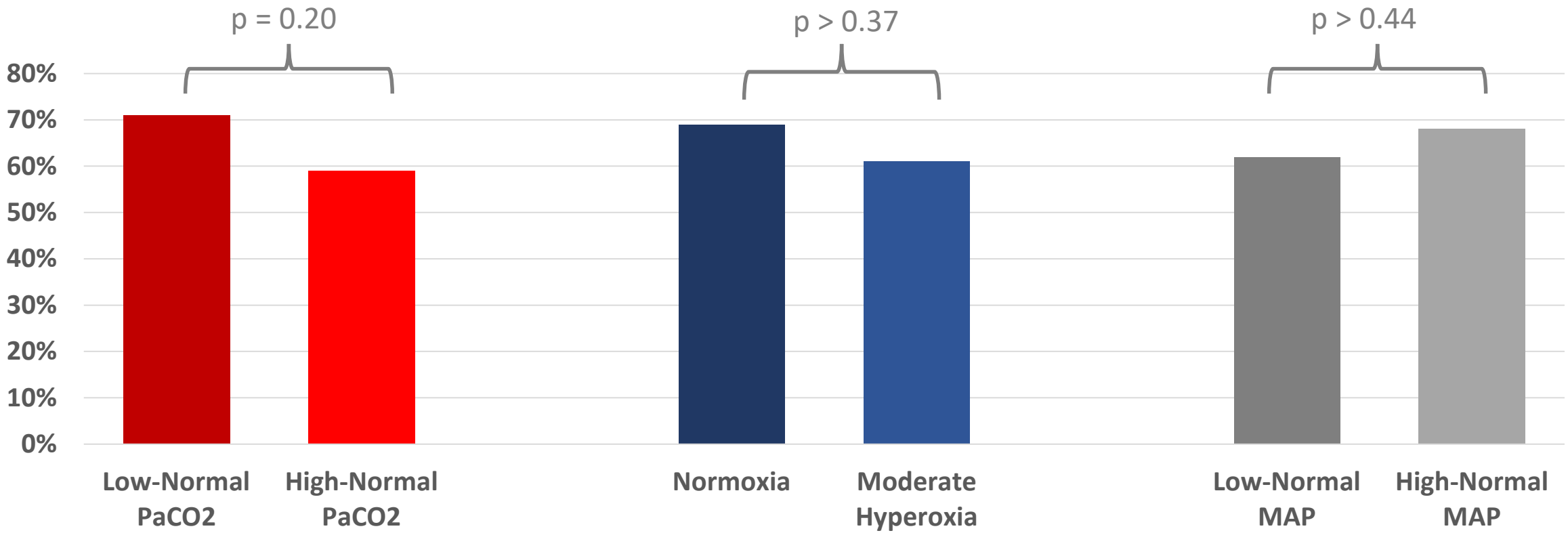


Brain Near-Infrared Spectroscopy (NIRS)

COMACARE Study

Jakkula ICM 2018

Survival with Good Neurologic Function (CPC 1-2)

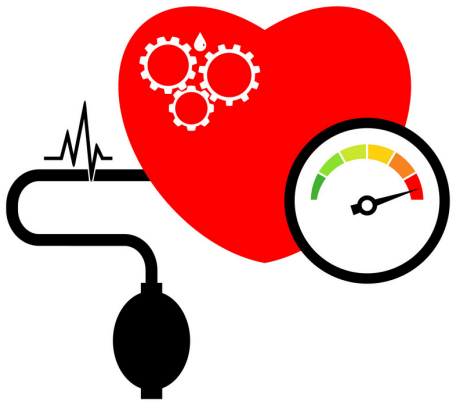


ESC European Society of Cardiology

European Heart Journal (2019) **40**, 1804–1814
doi:10.1093/eurheartj/ehz120

FASTTRACK CLINICAL RESEARCH
Disease management

Early goal-directed haemodynamic optimization of cerebral oxygenation in comatose survivors after cardiac arrest: the Neuroprotect post-cardiac arrest trial



Koen Ameloot[1,2,3]*, Cathy De Deyne[3,4], Ward Eertmans[3,4], Bert Ferdinande[1], Matthias Dupont[1], Pieter-Jan Palmers[1], Tibaut Petit[1,2], Philippe Nuyens[1,2], Joren Maeremans[1,3], Joris Vundelinckx[4], Maarten Vanhaverbeke[2], Ann Belmans[2], Ronald Peeters[5], Philippe Demaerel[5], Robin Lemmens[6,7,8], Jo Dens[1,3], and Stefan Janssens[2]

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

Ameloot Eur Heart J 2019

Design: Prospective, single center, randomized clinical trial

Setting: Adult ICU

Subjects: 112 unconscious OHCA patients with all presenting rhythms

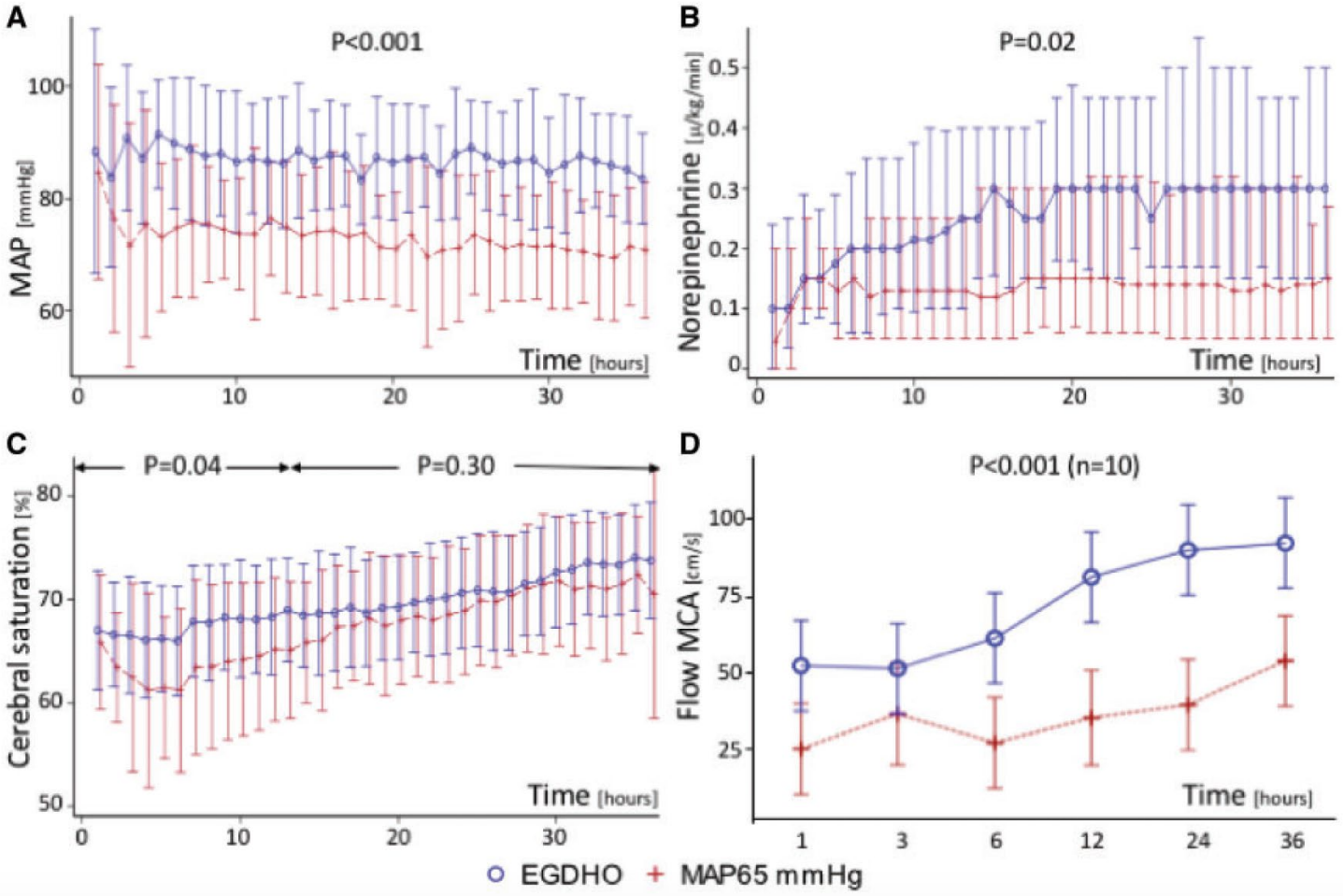
Intervention: Early goal-directed hemodynamic optimization **(EGDHO) MAP 80-100 mmHg + SVO_2 65-75%** **vs.** **MAP 65 mmHg** for first 36 hours in ICU

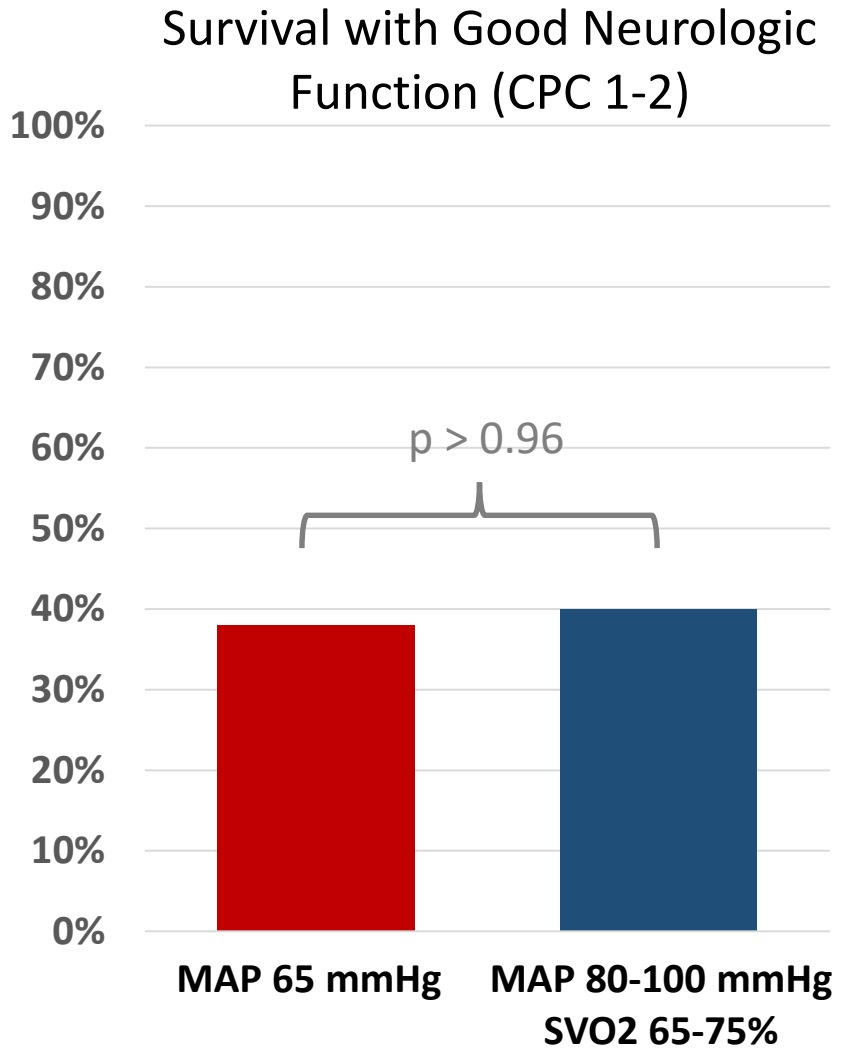
Primary Outcome: MRI evidence of anoxic brain injury

Secondary Outcome: Survival with good neurologic function (CPC 1-2) at 180 days

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

Ameloot Eur Heart J 2019





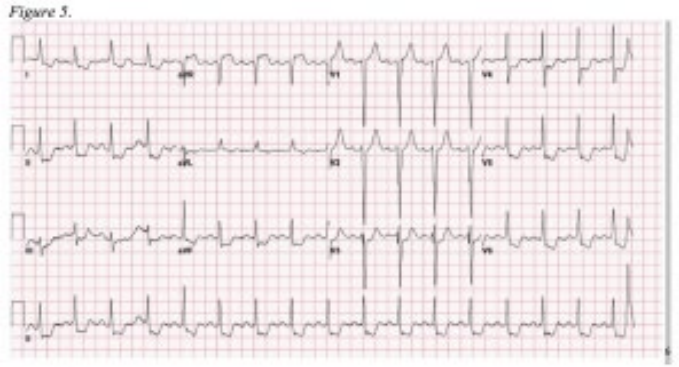
The NEW ENGLAND JOURNAL of MEDICINE

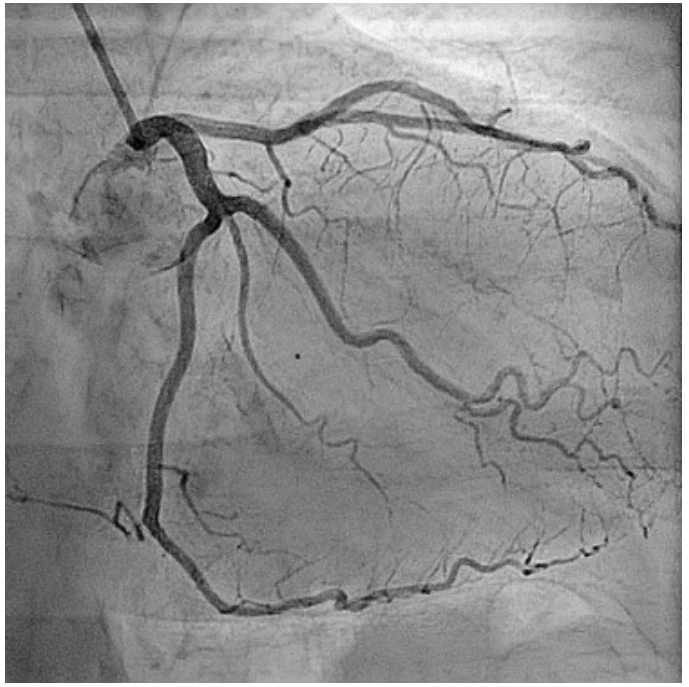
ESTABLISHED IN 1812 APRIL 11, 2019 VOL. 380 NO. 15

Coronary Angiography after Cardiac Arrest without ST-Segment Elevation

J.S. Lemkes, G.N. Janssens, N.W. van der Hoeven, L.S.D. Jewbali, E.A. Dubois, M. Meuwissen, T.A. Rijpstra, H.A. Bosker, M.J. Blans, G.B. Bleeker, R. Baak, G.J. Vlachojannis, B.J.W. Eikemans, P. van der Harst, I.C.C. van der Horst, M. Voskuil, J.J. van der Heijden, A. Beishuizen, M. Stoel, C. Camaro, H. van der Hoeven, J.P. Henriques, A.P.J. Vlaar, M.A. Vink, B. van den Bogaard, T.A.C.M. Heestermans, W. de Ruijter, T.S.R. Delnoij, H.J.G.M. Crijns, G.A.J. Jessurun, P.V. Oemrawsingh, M.T.M. Gosselink, K. Plomp, M. Magro, P.W.G. Elbers, P.M. van de Ven, H.M. Oudemans-van Straaten, and N. van Royen

Lemkes NEJM 2019





Coronary Angiography after Cardiac Arrest Without ST-Segment Elevation (COACT Trial)

Lemkes NEJM 2019

Design: Prospective randomize open-label multicenter clinical trial

Setting: Adult ICU

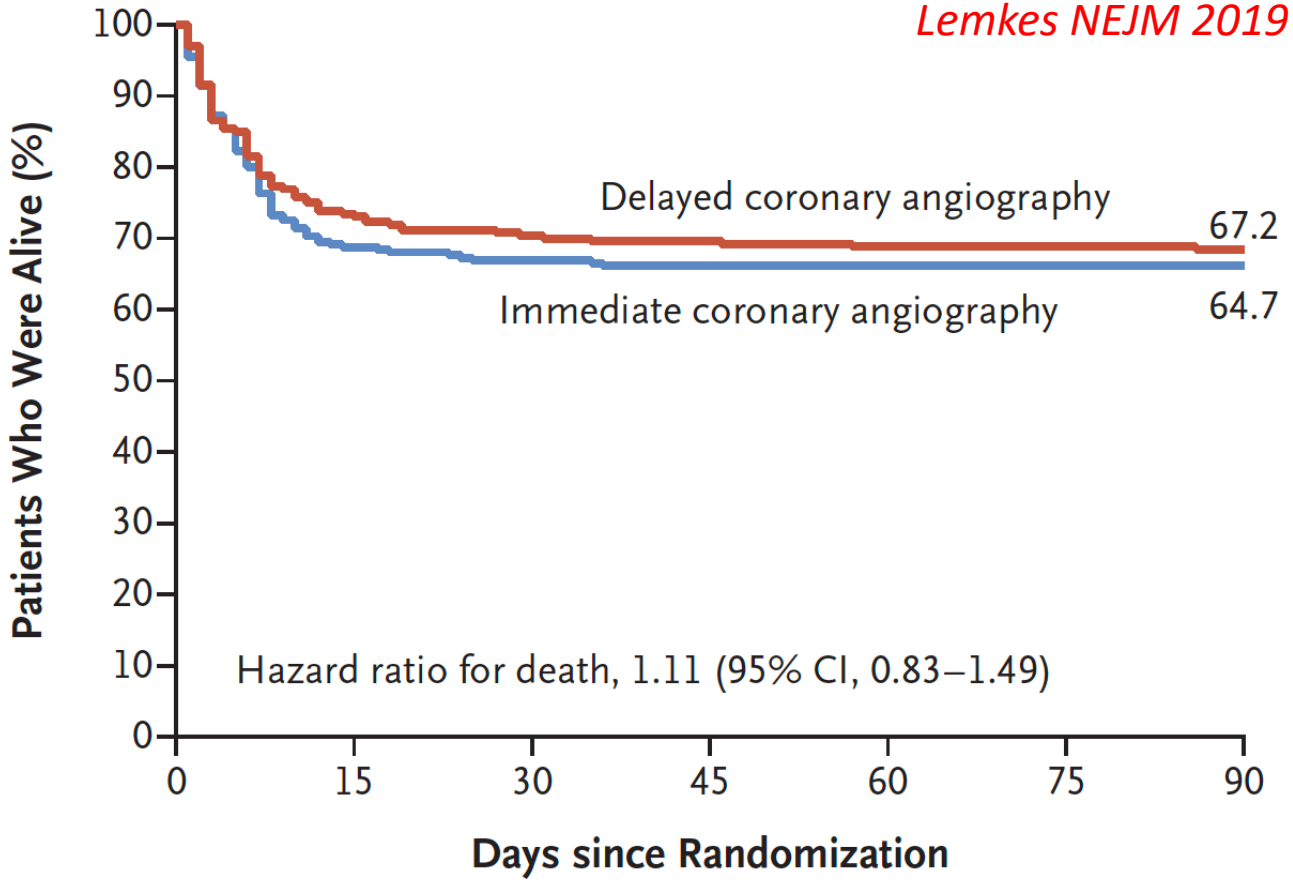
Subjects: 522 unconscious adult patients s/p OHCA who had initial shockable rhythm and without signs of STEMI, shock or obvious non-cardiac cause of the arrest

Intervention: Immediate coronary angiography vs. coronary angiography that was delayed until after neurologic recovery

Primary Outcome: Survival at 90 days

Coronary Angiography after Cardiac Arrest Without ST-Segment Elevation (COACT Trial)

Lemkes NEJM 2019



No. at Risk							
Delayed	265	191	183	181	179	179	178
Immediate	273	183	178	176	176	176	176

Incidence of acute thrombotic occlusion:

- 3.4% immediate angiography
- 7.6% delayed angiography

Time to target temperature (hrs):

- 6.5 (5.9 to 7.1) immediate angiography
- 5.5 (5.0 to 6.0) delayed angiography

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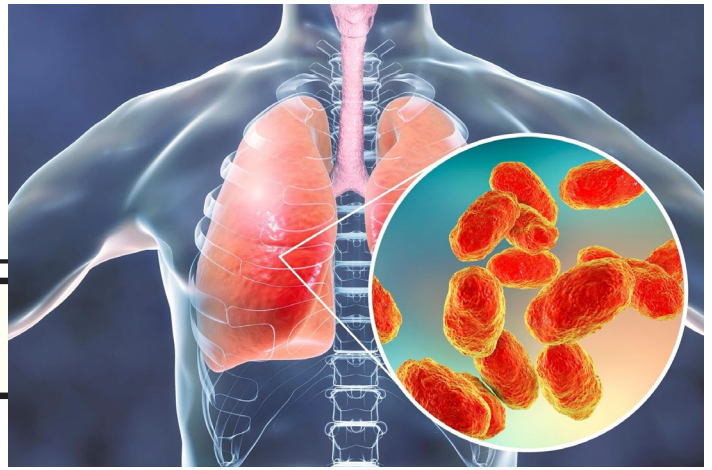


ORIGINAL ARTICLE

Prevention of Early Ventilator-Associated Pneumonia after Cardiac Arrest

B. François, A. Cariou, R. Clere-Jehl, P.-F. Dequin, F. Renon-Carron, T. Daix, C. Guitton, N. Deye, S. Legriel, G. Plantefève, J.-P. Quenot, A. Desachy, T. Kamel, S. Bedon-Carte, J.-L. Diehl, N. Chudeau, E. Karam, I. Durand-Zaleski, B. Giraudeau, P. Vignon, and A. Le Gouge, for the CRICS-TRIGGERSEP Network and the ANTHARTIC Study Group*

Francois NEJM 2019

Prevention of Early Ventilator Associated Pneumonia After Cardiac Arrest

Francois NEJM 2019

Design: Prospective multicenter, double-blind, randomized, placebo-controlled trial

Setting: Adult ICU

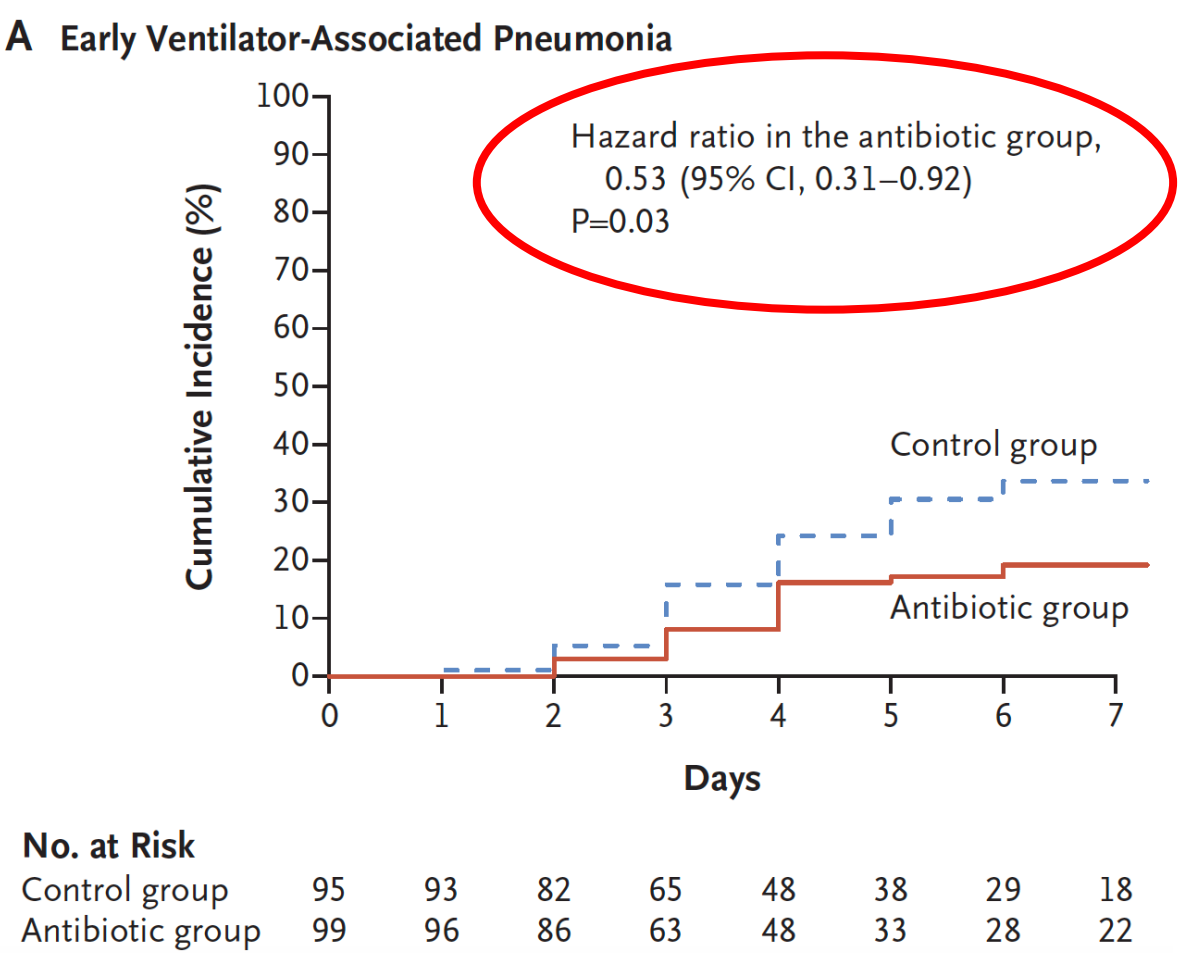
Subjects: 198 adult mechanically ventilated adult patients s/p witnessed OHCA who had initial shockable rhythm

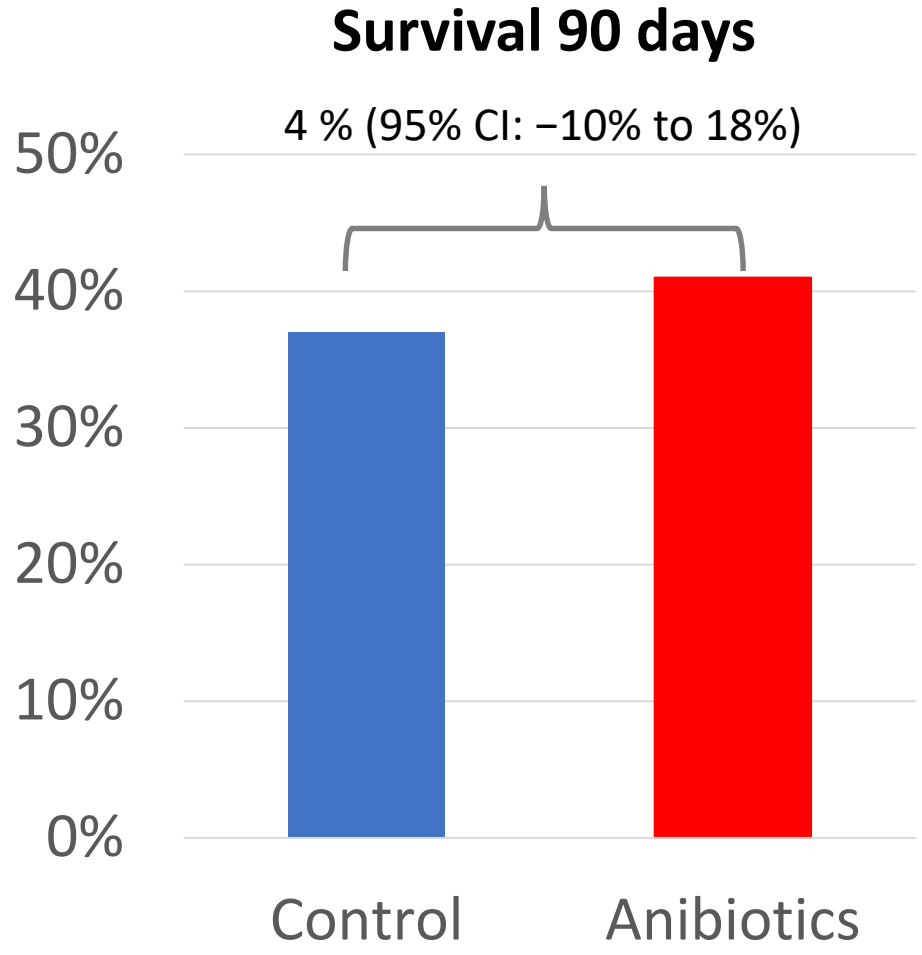
Intervention: Intravenous amoxicillin–clavulanate or placebo x 2 days starting less than 6 hours after the cardiac arrest.

Primary Outcome: Early ventilator-associated pneumonia (first 7 days of hospitalization).

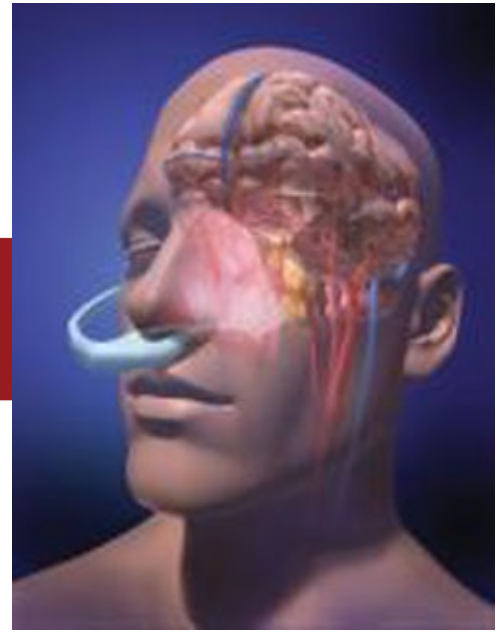
Prevention of Early Ventilator Associated Pneumonia After Cardiac Arrest

Francois NEJM 2019





Research



JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of Trans-Nasal Evaporative Intra-arrest Cooling on Functional Neurologic Outcome in Out-of-Hospital Cardiac Arrest

The PRINCESS Randomized Clinical Trial

Per Nordberg, MD, PhD; Fabio Silvio Taccone, MD, PhD; Anatolij Truhlar, MD, PhD; Sune Forsberg, MD, PhD; Jacob Hollenberg, MD, PhD; Martin Jonsson, MSc; Jerome Cuny, MD; Patrick Goldstein, MD; Nick Vermeersch, MD; Adeline Higuet, MD; Francisco Carmona Jiménes, MD; Fernando Rosell Ortiz, MD, PhD; Julia Williams, MD, PhD; Didier Desruelles, MD; Jacques Creteur, MD, PhD; Emelie Dillenbeck, MD; Caroline Busche, MD; Hans-Jörg Busch, MD; Mattias Ringh, MD, PhD; David Konrad, MD, PhD; Johan Peterson, MD, PhD; Jean-Louis Vincent, MD, PhD; Leif Svensson, MD, PhD

PRINCESS Trial

Nordberg JAMA 2019

Design: Prospective multicenter open-label randomized controlled clinical trial

Setting: Out-of-hospital

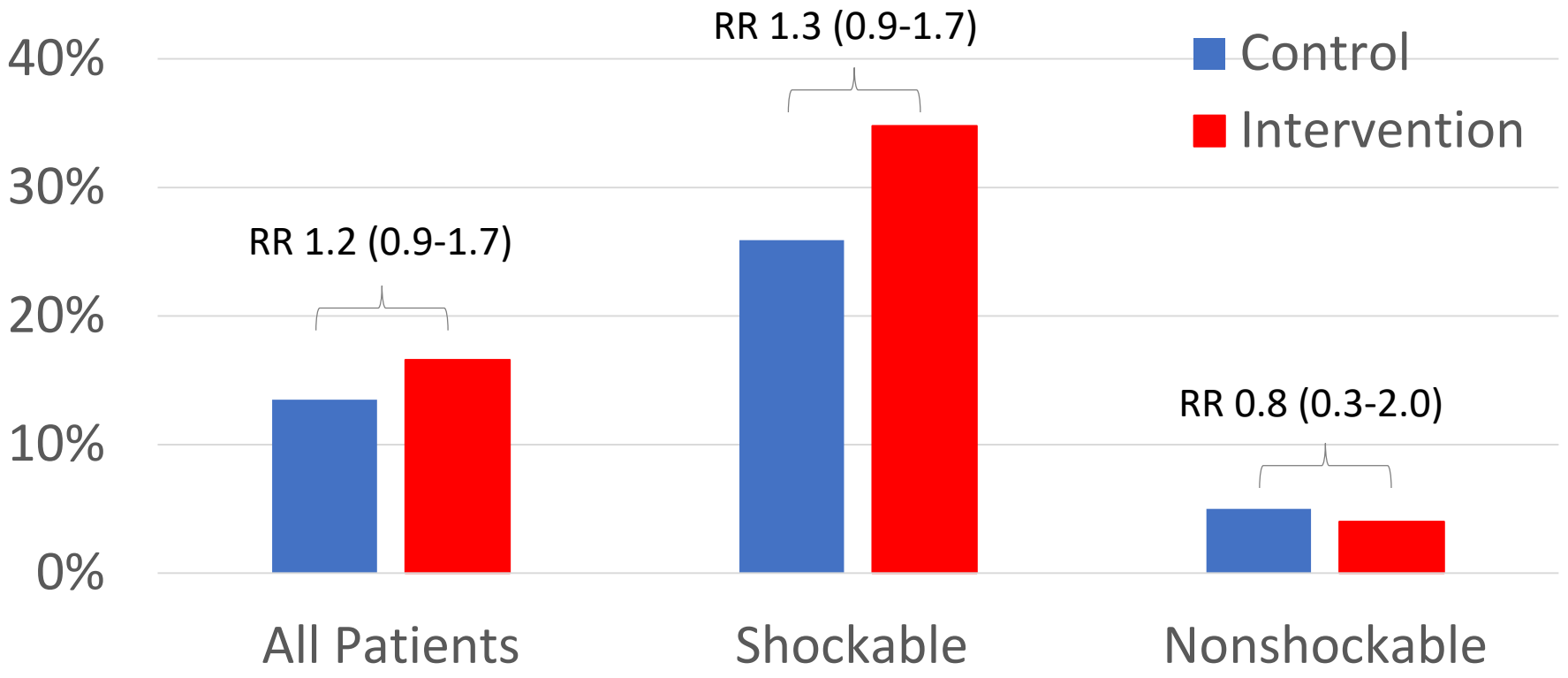
Subjects: 677 adult patients with bystander witnessed OHCA

Intervention: Intra-arrest transnasal evaporative cooling vs. standard care

Primary Outcome: Survival with good neurologic function (CPC 1-2 at 90 days)

PRINCESS Trial

Nordberg JAMA 2019

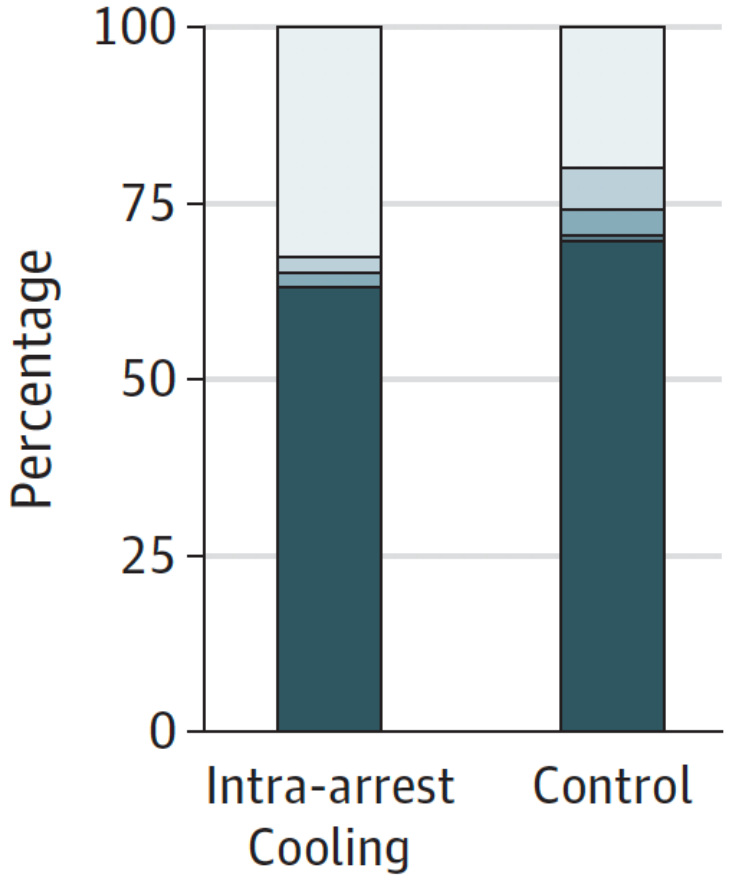


PRINCESS Trial

Nordberg JAMA 2019

B Patients with shockable rhythm

CPC Score	No. (%) Intra-arrest Cooling	Control	Difference, % (95% CI)
CPC 1	45 (32.6)	27 (20.0)	12.6 (2.3 to 22.9)
CPC 2	3 (2.2)	8 (5.9)	-3.8 (-8.4 to 0.9)
CPC 3	3 (2.2)	5 (3.7)	-1.5 (-5.5 to 2.5)
CPC 4	0 (0.0)	1 (0.7)	-0.7 (-2.2 to 0.7)
CPC 5	87 (63.0)	94 (69.6)	-6.6 (-17.8 to 4.6)



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Targeted Temperature Management for Cardiac Arrest with Nonshockable Rhythm

J.-B. Lascarrou, H. Merdji, A. Le Gouge, G. Colin, G. Grillet, P. Girardie, E. Coupez, P.-F. Dequin, A. Cariou, T. Boulain, N. Brule, J.-P. Frat, P. Asfar, N. Pichon, M. Landais, G. Plantefeve, J.-P. Quenot, J.-C. Chakarian, M. Sirodot, S. Legriel, J. Letheulle, D. Thevenin, A. Desachy, A. Delahaye, V. Botoc, S. Vimeux, F. Martino, B. Giraudeau, and J. Reignier, for the CRICS-TRIGGERSEP Group*

Lascarrou NEJM 2019

HYPERION Trial

Lascarrou NEJM 2019

Design: Prospective open-label multicenter randomized controlled clinical trial

Setting: Adult ICU

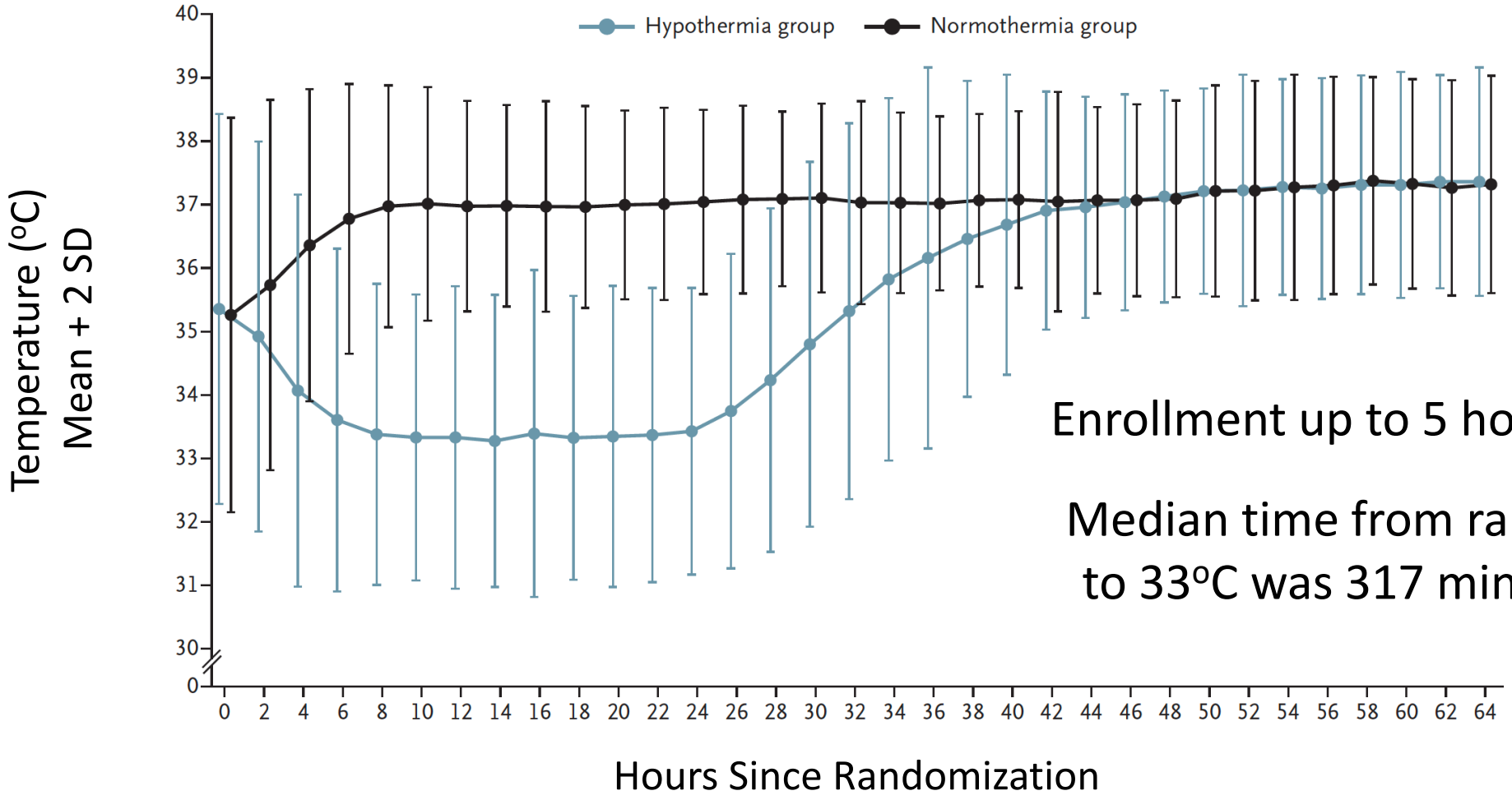
Subjects: 584 adult comatose patients following IHCA (27%) or OHCA (73%) with nonshockable initial rhythm

Intervention: 33°C vs. 37°C during the first 24 hours

Primary Outcome: Survival with good neurologic function (CPC 1-2 at 90 days)

HYPERION Trial

Lascarrou NEJM 2019

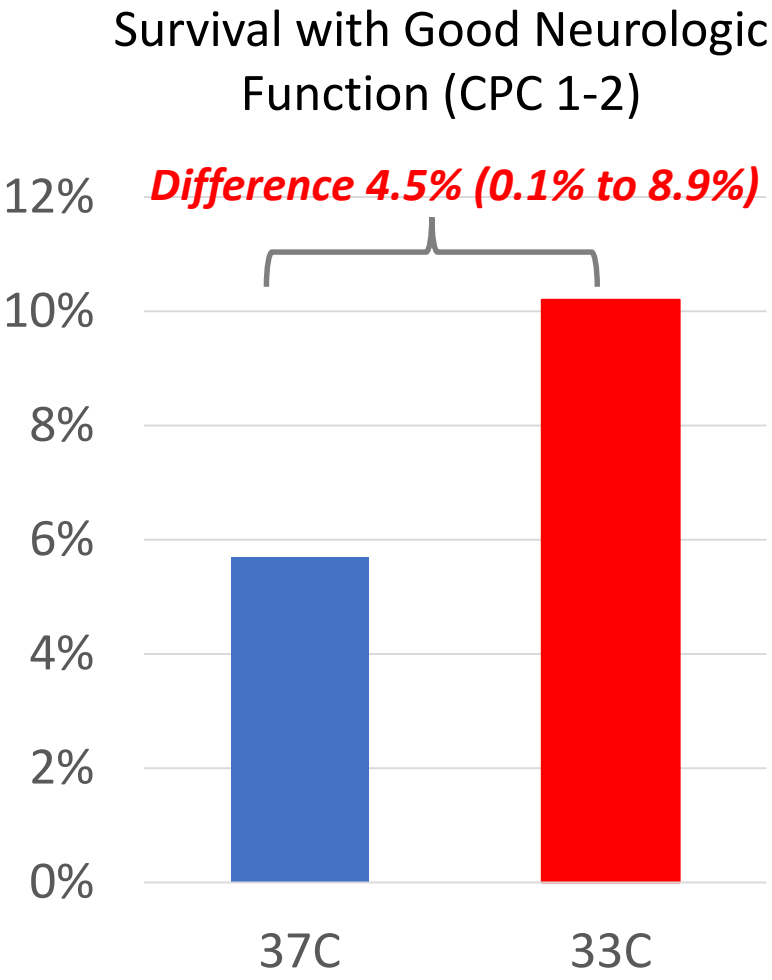


Enrollment up to 5 hours post-ROSC

Median time from randomization to 33°C was 317 min [214 ; 477]

HYPERION Trial

Lascarrou NEJM 2019



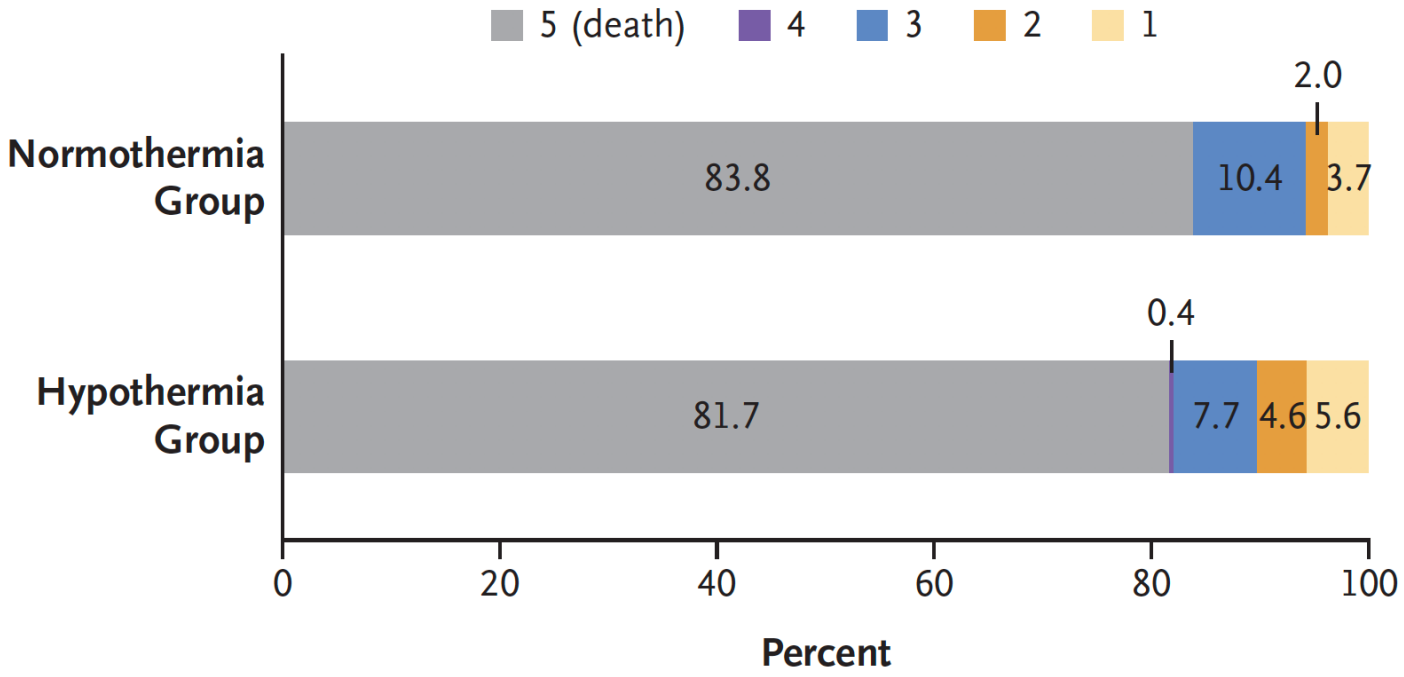


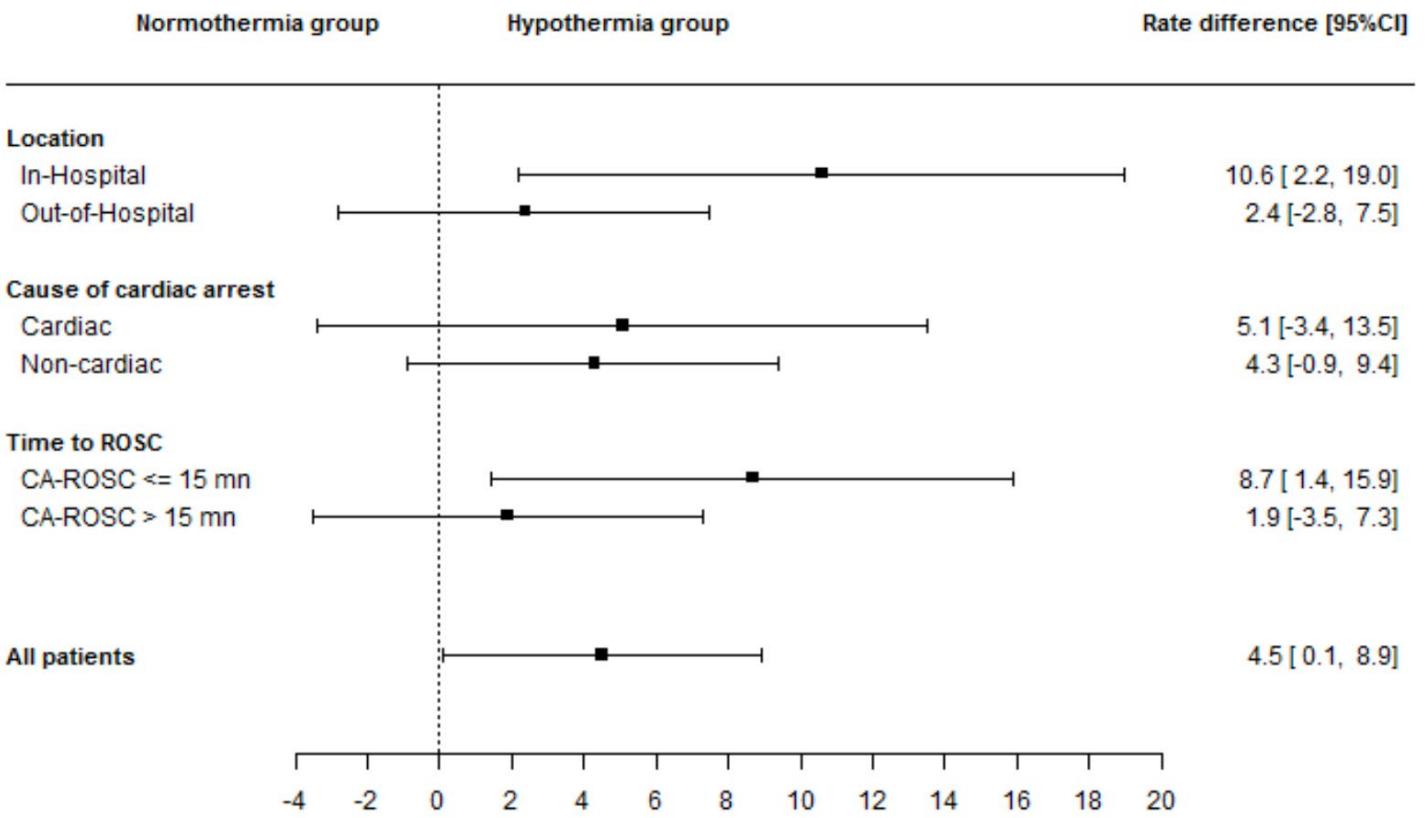
Figure 3. **Distribution of Cerebral Performance Category Scores on Day 90 after Randomization.**

HYPERION Trial

Lascarrou NEJM 2019

Subgroup Analysis

Survival with Good Neurologic Function (CPC 1-2)

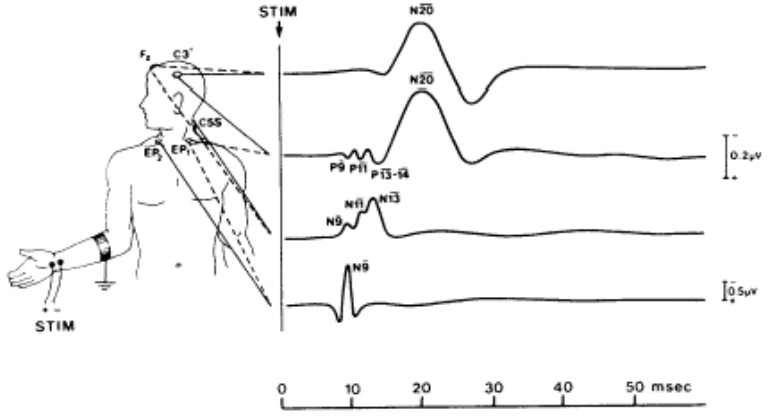


RESUSCITATION 143 (2019) 115–123

Available online at www.sciencedirect.com

Resuscitation

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



Clinical paper

Neurophysiology and neuroimaging accurately predict poor neurological outcome within 24 hours after cardiac arrest: The ProNeCA prospective multicentre prognostication study

Maenia Scarpino[a,b], *Francesco Lolli*[c], *Giovanni Lanzo*[a], *Riccardo Carrai*[a,b], *Maddalena Spalletti*[a], *Franco Valzania*[d], *Maria Lombardi*[e], *Daniela Audenino*[f], *Maria Grazia Celani*[g], *Alfonso Marrelli*[h], *Sara Contardi*[i], *Adriano Peris*[l], *Aldo Amantini*[a,b], *Claudio Sandroni*[m,*], *Antonello Grippo*[a,b], *for the ProNeCA Study Group*[1]

ProNeCA Study

Scarpino Resuscitation 2019

Design: Prospective multicenter prognostication study

Setting: 13 mixed medical-surgical intensive care units(ICUs)

Population: Adult comatose cardiac arrest survivors admitted to ICU

Variables Studied: Somatosensory evoked potentials (SSEP), Brain CT, and EEG

Outcome: Poor neurologic outcome (CPC 4-5) at 6 months

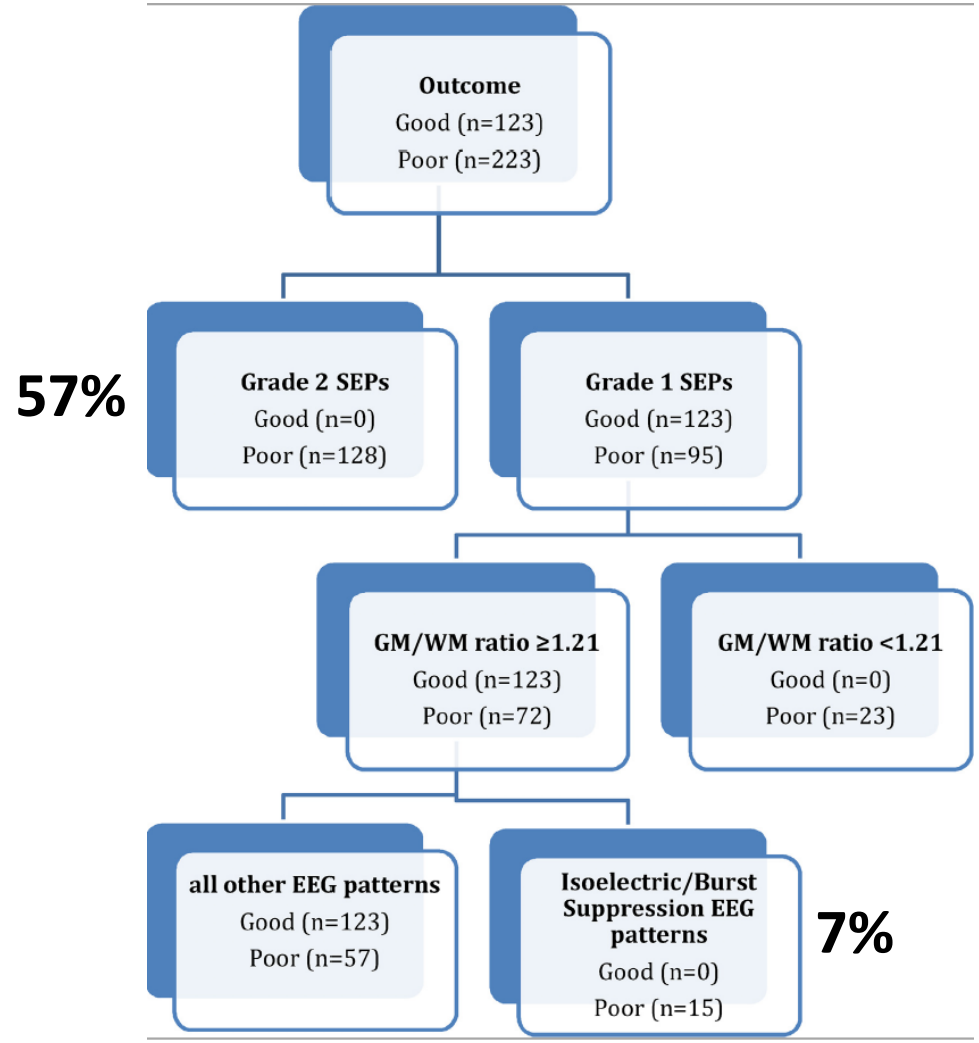
"Withdrawal of life sustaining therapy (WLST) was not performed in any of the participating centres and treatment was continued in all patients, except when brain death occurred."

ProNeCA Study

Scarpino Resuscitation 2019

Multimodal

- Grade 2 SSEP or CT G/W ratio <1.21 or highly malignant EEG
- ≤24 hours
- **FPR 0% (0-3%)**
- Sensitivity 74.4% (68-80%)

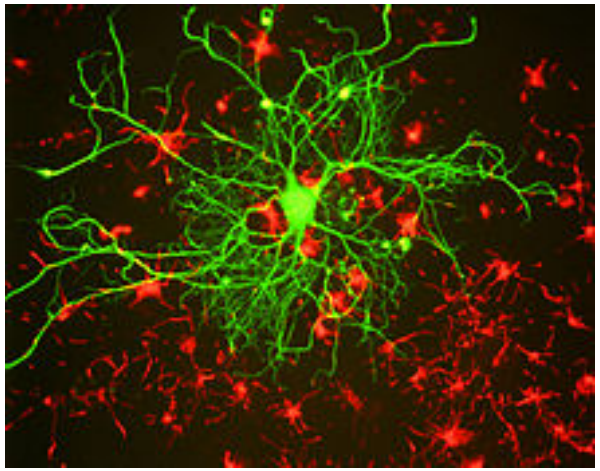


Research

JAMA Neurology | Original Investigation

Serum Neurofilament Light Chain for Prognosis of Outcome After Cardiac Arrest

Marion Moseby-Knappe, MD; Niklas Mattsson, PhD; Niklas Nielsen, PhD; Henrik Zetterberg, PhD; Kaj Blennow, PhD; Josef Dankiewicz, PhD; Irina Dragancea, PhD; Hans Friberg, PhD; Gisela Lilja, PhD; Philip S. Insel, MS; Christian Rylander, PhD; Erik Westhall, PhD; Jesper Kjaergaard, PhD; Matt P. Wise, PhD; Christian Hassager, PhD; Michael A. Kuiper, PhD; Pascal Stammet, PhD; Michael C. Jaeger Wanscher, PhD; Jørn Wetterslev, PhD; David Erlinge, PhD; Janneke Horn, PhD; Tommaso Pellis, MD; Tobias Cronberg, PhD



Moseby-Knappe JAMA Neurology 2018

Serum Neurofilament Light Chain (NFL) for Prognosis of Outcome after Cardiac Arrest

Moseby-Knappe JAMA Neurology 2018

Design: Prospective clinical biobank study of data from TTM trial

Setting: International multicenter study with 29 participating sites

Population: 782 unconscious patients with out-of-hospital cardiac arrest of presumed cardiac origin

Variables Studied: Serum NFL concentrations analyzed at 24, 48, and 72 hours after cardiac arrest

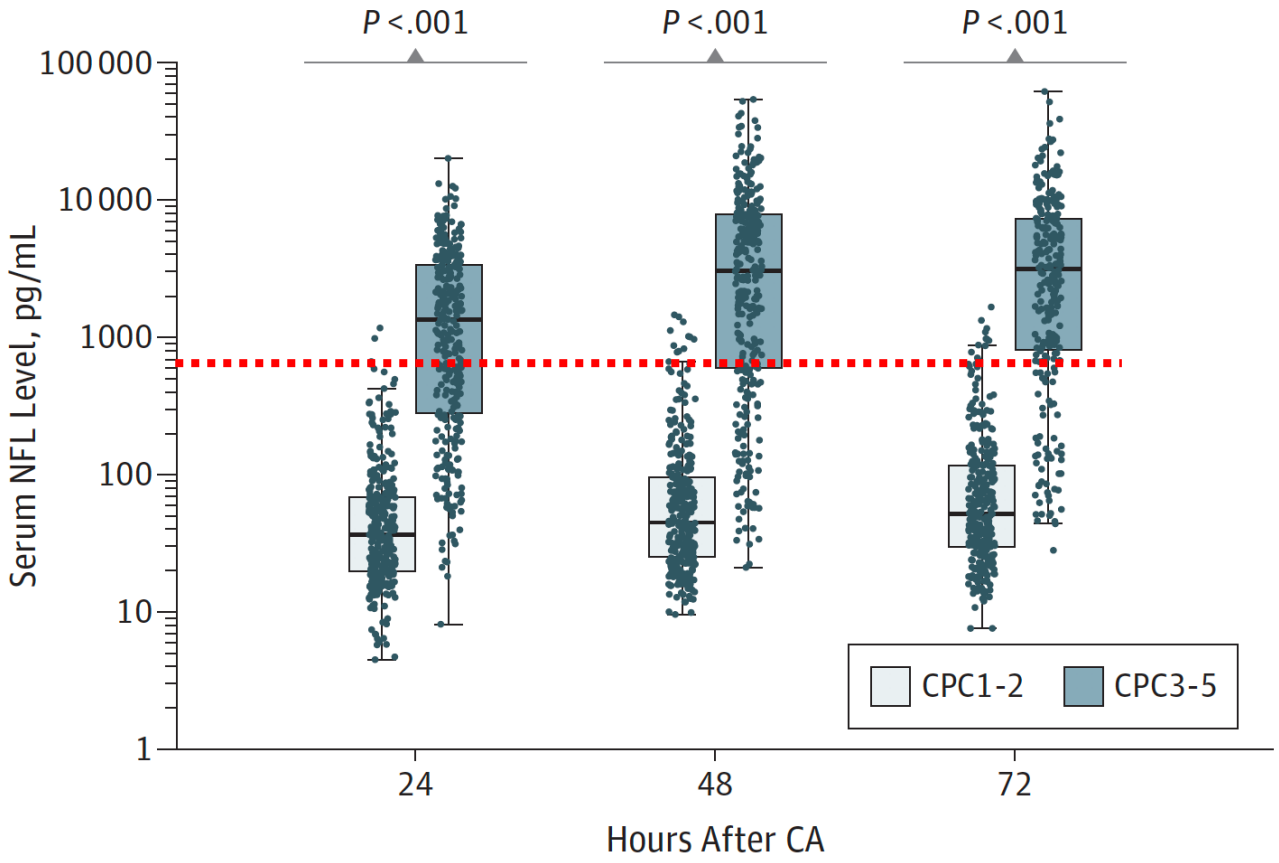
Outcome: Poor neurologic outcome at 6-months (CPC 3-5)

Serum Neurofilament Light Chain (NFL) for Prognosis of Outcome after Cardiac Arrest

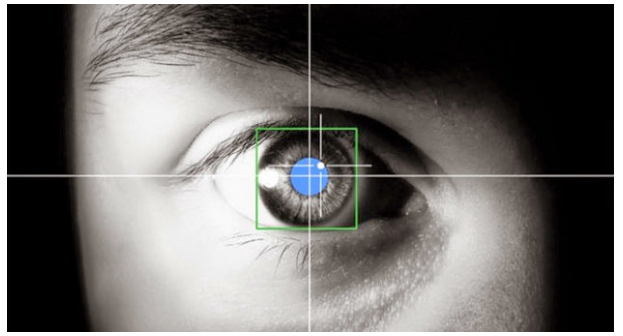
Moseby-Knappe JAMA Neurology 2018

Serum NFL

- > 641 pg/mL
- 24 hours post-ROSC
- **FPR <1% (0-5%)**
- Sensitivity 31%
- 50% TTM_{33} and 50% TTM_{36}



Intensive Care Med
https://doi.org/10.1007/s00134-018-5448-6



ORIGINAL

Quantitative versus standard pupillary light reflex for early prognostication in comatose cardiac arrest patients: an international prospective multicenter double-blinded study

Mauro Oddo[1*], Claudio Sandroni[2], Giuseppe Citerio[3,4], John-Paul Miroz[1], Janneke Horn[5], Malin Rundgren[6], Alain Cariou[7,8], Jean-François Payen[9], Christian Storm[10], Pascal Stammet[11] and Fabio Silvio Taccone[12]

Quantitative Pupillometry: Neural Pupillary Index (Npi®)

Oddo ICM 2019

Design: Prospective international multicenter observational study

Setting: 10 adult ICUs

Population: Comatose cardiac arrest survivors

Variables Studied: Quantitative neurological pupil index (Npi) and standard manual pupillary light reflex (sPLR) day 1 to 3 after cardiac arrest

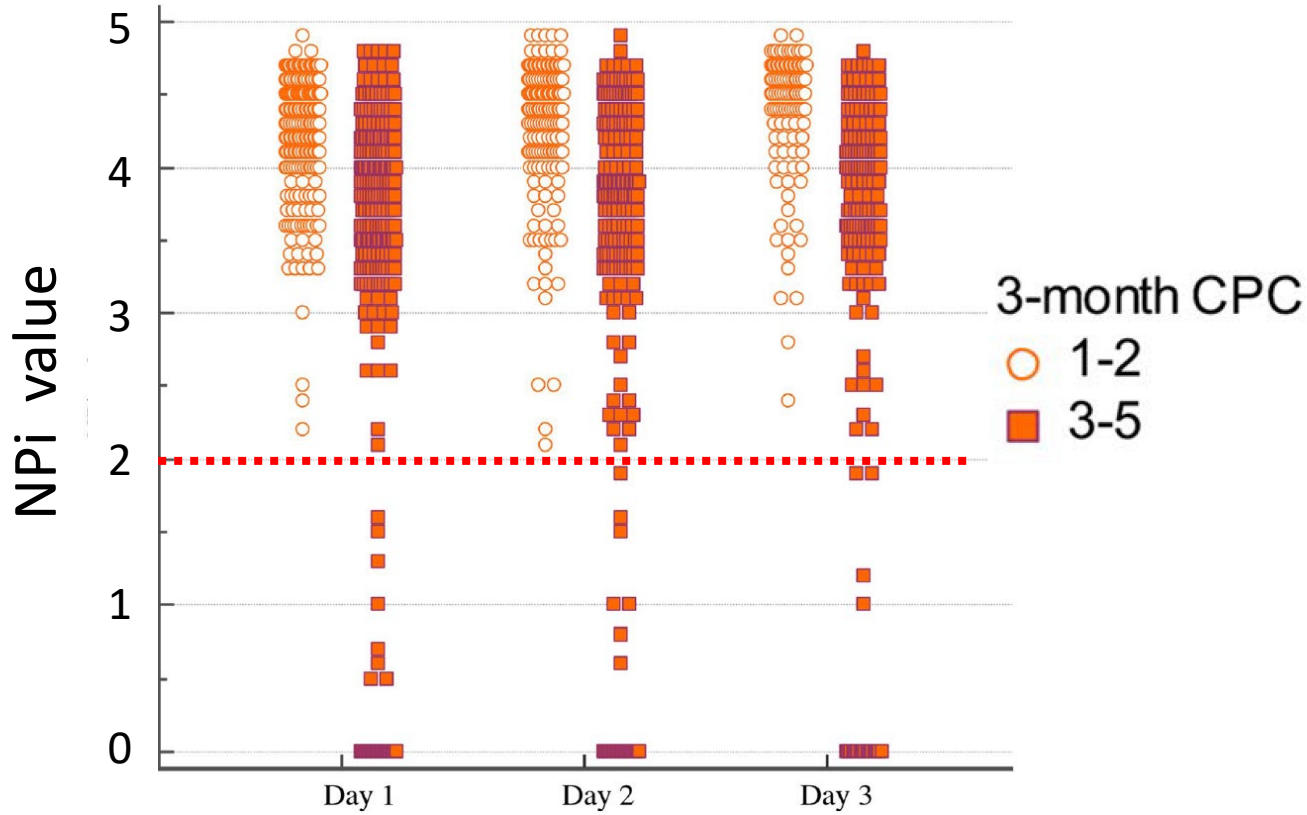
Outcome: Poor outcome defined as CPC 3-5 (severe disability, vegetative state, or death) at 3-months

Quantitative Pupillometry: Neurological Pupil Index (Npi®)

Oddo ICM 2019

Neurological Pupil Index

- NPi* <2.0
- First 24 hours post-ROSC
- **FPR 0% (0-2%)**
- Sensitivity 22%
- 42% TTM_{33} 40% TTM_{36}



* NPi®-200 pupillometer, Neuroptics®, Irvine, CA, USA

Brain-*Ex*

NATIONAL GEOGRAPHIC

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SCIENCE

Pig brains partially revived hours after death—what it means for people

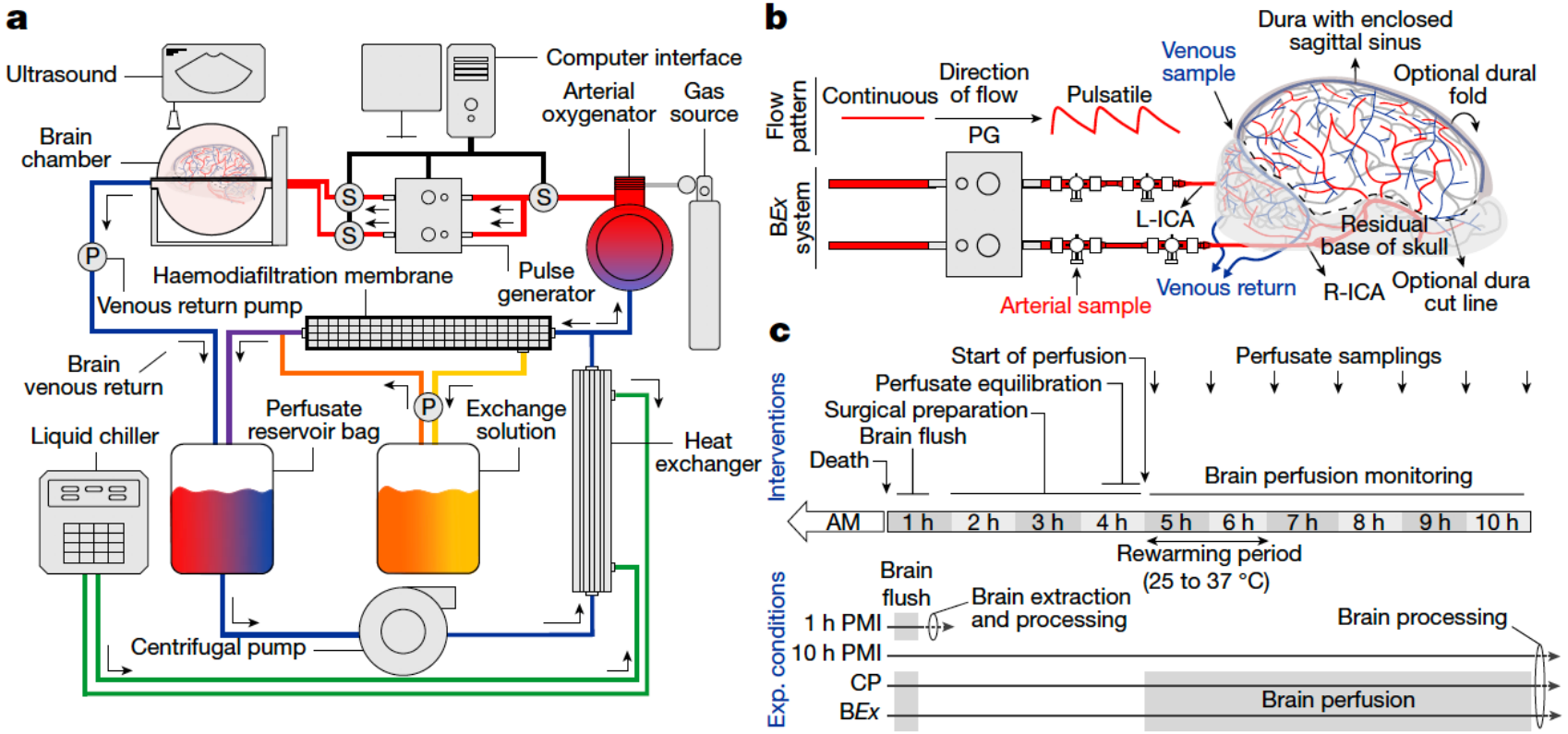
In a feat sure to fire up ethical and philosophical debate, a new system has restored circulation and oxygen flow to a dead mammal brain.

ARTICLE

NATURE 2019

https://doi.org/10.1038/s41586-019-1099-1

Restoration of brain circulation and cellular functions hours post-mortem

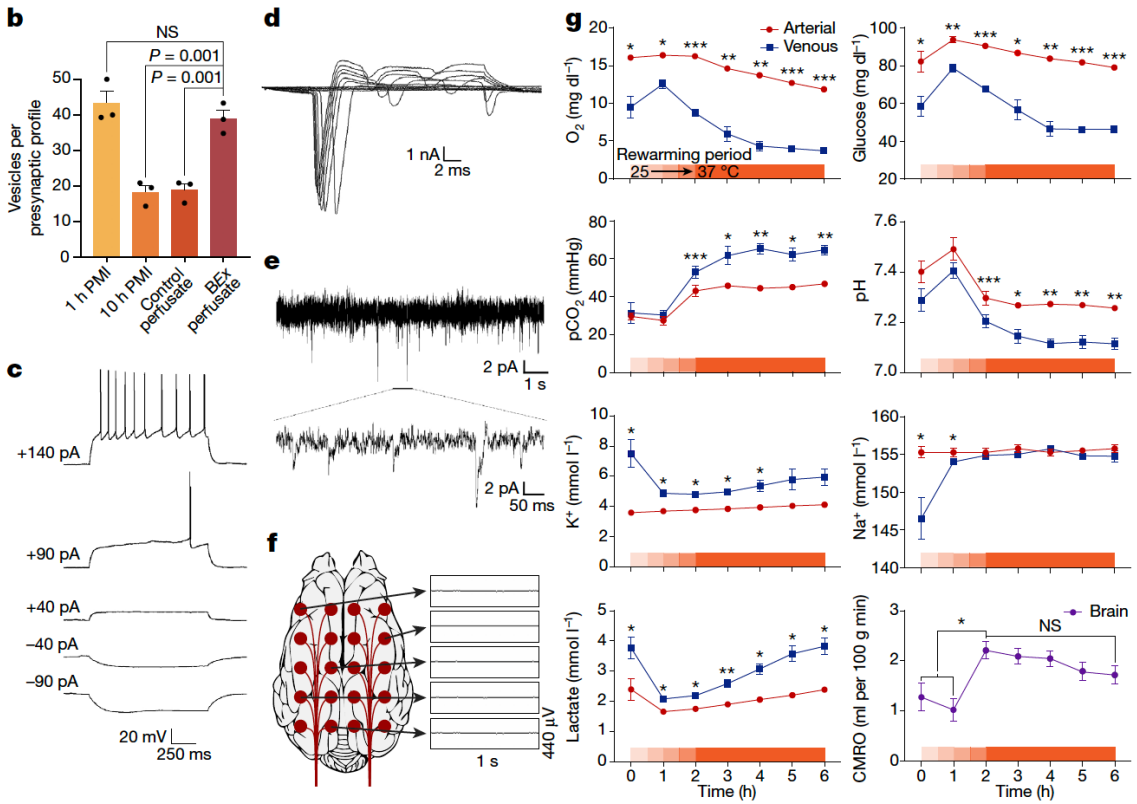


https://doi.org/10.1038/s41586-019-1099-1

Restoration of brain circulation and cellular functions hours post-mortem

NATURE 2019

Zvonimir Vrselja[1,2,18], Stefano G. Daniele[1,2,3,18], John Silbereis[1,2], Francesca Talpo[1,2,4], Yury M. Morozov[1,2], André M. M. Sousa[1,2], Brian S. Tanaka[5,6,7], Mario Skarica[1,2], Mihovil Pletikos[1,2,8], Navjot Kaur[1,2], Zhen W. Zhuang[9], Zhao Liu[9,10], Rafeed Alkawadri[6,11], Albert J. Sinusas[9,10], Stephen R. Latham[12], Stephen G. Waxman[5,6,7] & Nenad Sestan[1,2,13,14,15,16,17]*



OBSERVED

- Preservation of cytoarchitecture
- Attenuation of cell death
- Vascular dilatory responses
- Glial inflammatory responses
- Spontaneous synaptic activity
- Active cerebral metabolism

NOT OBSERVED

- Global electrocortical activity

What Did We Learn In 2019?

- Ventilation rates in pediatric CPR need to be re-evaluated
- Post-cardiac arrest normoxia, normocarbia, and normotension are reasonable. Studies needed to evaluate individualized goal-directed strategies
- Empiric antibiotics prevented pneumonia in post-cardiac arrest patients treated with hypothermic TTM but did not improves survival
- Immediate post-cardiac arrest PCI for patients without STEMI criteria does not improve survival in a population with low incidence of acute coronary occlusion

What Did We Learn In 2019?

- Intra-arrest intranasal evaporative cooling does not improve overall survival with good neurologic function in bystander witnessed OHCA, but may benefit subpopulations such as those with an initial shockable rhythm
- TTM at 33^{o}C improves survival with good neurologic function compared to TTM at 37^{o}C in post-cardiac arrest patients with non-shockable initial rhythm
- Reliable neuroprognostication of futility within 24 hours of ROSC may be feasible using a multimodal approach
- Brain*Ex* has challenged the limits of total brain ischemia after which restoration of brain function can be achieved.

Circulation

AHA 2019 Focused Updates for First Aid, CPR, and Emergency Cardiovascular Care

Year in Review: Cardiac Arrest 2019

neumar@umich.edu

Robert W. Neumar, MD, PhD
Professor and Chair,
Department of Emergency Medicine
University of Michigan
Ann Arbor, Michigan, USA

@neumar_robert

Resuscitation Science Symposium 2019

Nov. 16–17, 2019

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