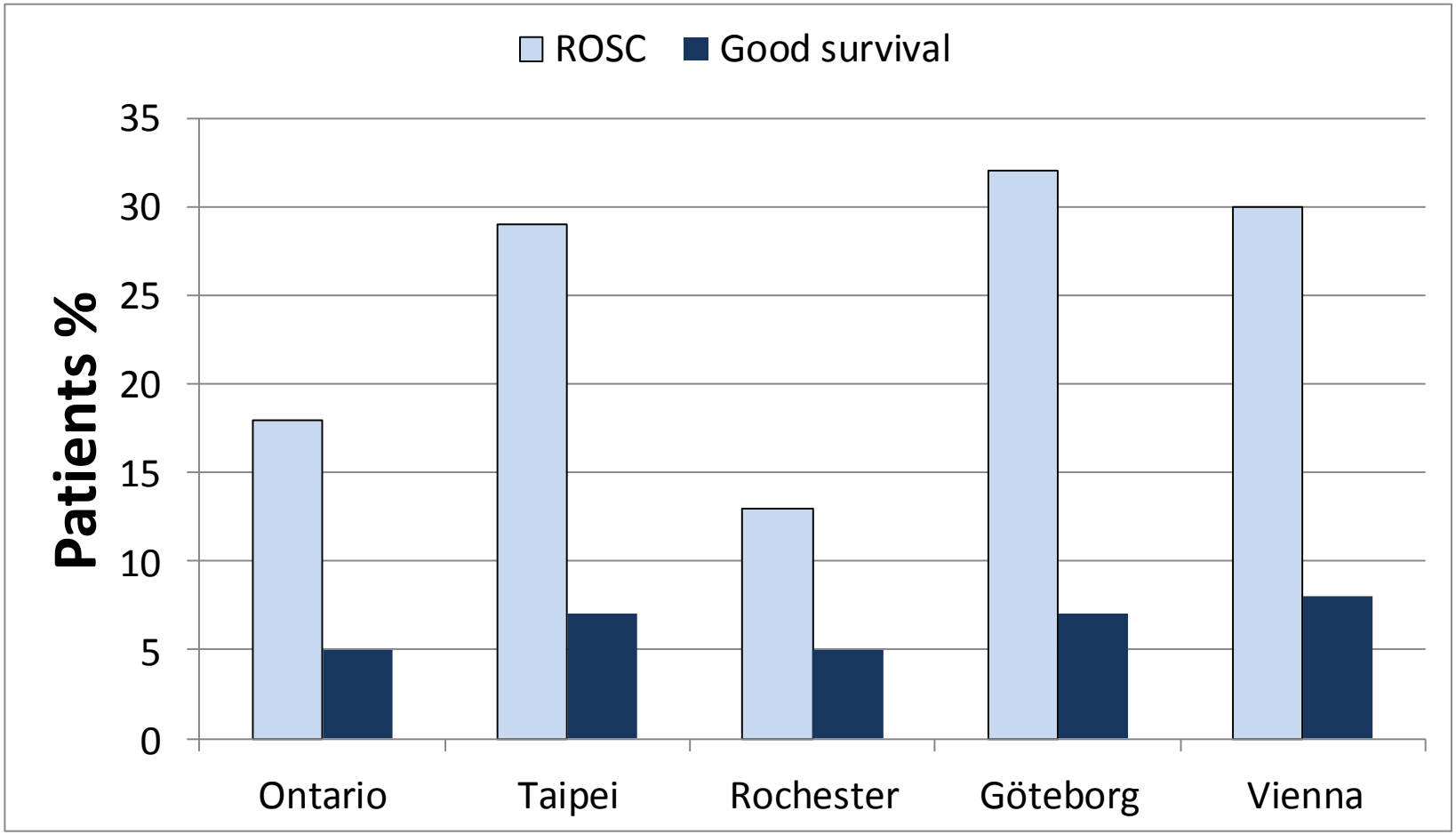
Management of Post Cardiac Arrest Syndrome

Wilhelm Behringer

Associated Professor of Emergency Medicine

Medical University of Vienna, Austria

What happens after ROSC?



Stiell, NEJM 2004
Werling, Resuscitation 2007

MA, Resuscitation 2007
Fairbanks, Resuscitation 2007
Nürnberber, Resuscitation 2012

What happens after ROSC?

The importance of good quality post resuscitation care

Mary Ann Peberdy*
Joseph P. Ornato

ELSEVIER

Resuscitation 64 (2005) 135–137

RESUSCITATION

www.elsevier.com/locate/resuscitation

Editorial

Post-resuscitation care: is it the missing link in the Chain of Survival?

What happens after ROSC?

Resuscitation 81 (2010) 1219–1276

Contents lists available at ScienceDirect

Resuscitation

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

European Resuscitation Council Guidelines for Resuscitation 2010
Section 1. Executive summary

Jerry P. Nolan[a,*], Jasmeet Soar[b], David A. Zideman[c], Dominique Biarent[d], Leo L. Bossaert[e], Charles Deakin[f], Rudolph W. Koster[g], Jonathan Wyllie[h], Bernd Böttiger[i], on behalf of the ERC Guidelines Writing Group[1]

- **Emphasis on the treatment of the postcardiac arrest syndrome**
- **Structured post-resuscitation treatment protocol**
  - **Ventilation – oxygenation**
  - **Reperfusion PCI**
  - **Glucose control**
  - **Therapeutic hypothermia**

Overview

- Introduction
- **Ventilation and oxygenation strategies**
- Reperfusion strategies
- Metabolic control
- Mild therapeutic hypothermia
- Conclusions and recommendations

Ventilation and oxygenation

Association Between Arterial Hyperoxia Following Resuscitation From Cardiac Arrest and In-Hospital Mortality

J. Hope Kilgannon, MD
Alan E. Jones, MD
Nathan I. Shapiro, MD, MPH
Mark G. Angelos, MD
Barry Milcarek, PhD
Krystal Hunter, MBA
Joseph E. Parrillo, MD
Stephen Trzeciak, MD, MPH
for the Emergency Medicine Shock Research Network (EMShockNet) Investigators

Context Laboratory investigations suggest that exposure to hyperoxia after resuscitation from cardiac arrest may worsen anoxic brain injury; however, clinical data are lacking.

Objective To test the hypothesis that postresuscitation hyperoxia is associated with increased mortality.

Design, Setting, and Patients Multicenter cohort study using the Project IMPACT critical care database of intensive care units (ICUs) at 120 US hospitals between 2001 and 2005. Patient inclusion criteria were age older than 17 years, nontraumatic cardiac arrest, cardiopulmonary resuscitation within 24 hours prior to ICU arrival, and arterial blood gas analysis performed within 24 hours following ICU arrival. Patients were divided into 3 groups defined a priori based on PaO_2 on the first arterial blood gas values obtained in the ICU. Hyperoxia was defined as PaO_2 of 300 mm Hg or greater; hypoxia, PaO_2 of less than 60 mm Hg (or ratio of PaO_2 to fraction of inspired oxygen <300); and normoxia, not classified as hyperoxia or hypoxia.

Main Outcome Measure In-hospital mortality.

Results Of 6326 patients, 1156 had hyperoxia (18%), 3999 had hypoxia (63%), and 1171 had normoxia (19%). The hyperoxia group had significantly higher in-hospital mortality (732/1156 [63%; 95% confidence interval {CI), 60%-66%]) compared with the normoxia group (532/1171 [45%; 95% CI, 43%-48%]; proportion difference, 18% [95% CI, 14%-22%]) and the hypoxia group (2297/3999 [57%; 95% CI, 56%-59%]; proportion difference, 6% [95% CI, 3%-9%]). In a model controlling for potential confounders (eg, age, preadmission functional status, comorbid conditions, vital signs, and other physiological indices), hyperoxia exposure had an odds ratio for death of 1.8 (95% CI, 1.5-2.2).

Conclusion Among patients admitted to the ICU following resuscitation from cardiac arrest, arterial hyperoxia was independently associated with increased in-hospital mortality compared with either hypoxia or normoxia.

JAMA. 2010;303(21):2165-2171 www.jama.com

SUDDEN CARDIAC ARREST IS THE most common lethal consequence of cardiovascular disease. Even if return of spontaneous circulation (ROSC) from cardiac arrest is achieved, approximately 60% of patients will not survive to hospital discharge.[1,2] The high mortality is attributed to the postcardiac arrest syndrome, which involves global ischemia-reperfusion injury, myocardial stunning, and anoxic brain injury.[3] The recent success of therapeutic hypother-

6.326 Patients after CA

1st arterial BG in ICU

- **Hyperoxia: PaO2 > 300 mmHg (18%)**
- **Hypoxia: PaO2 < 60 mmHg (63%)**
- **Normoxia: not classified as hyperoxia or hypoxia (19%)**

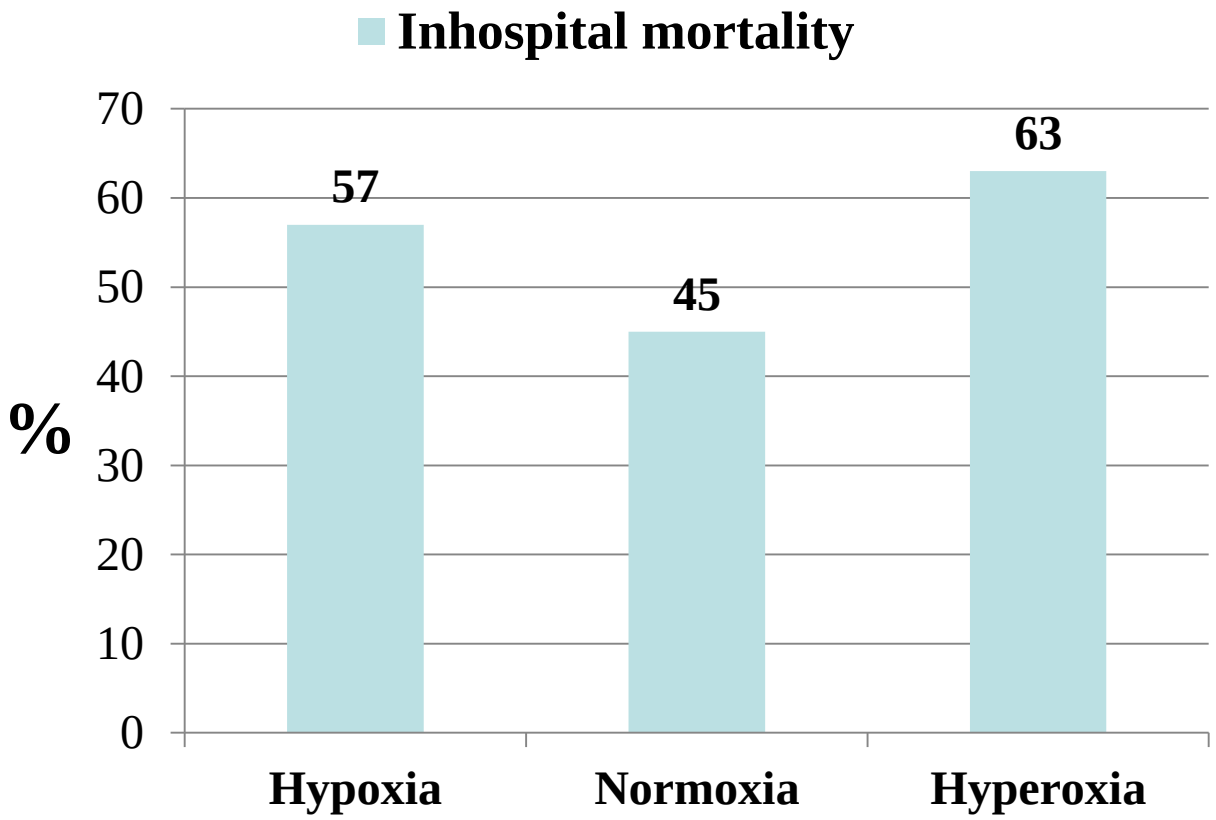
Ventilation and oxygenation

Association Between Arterial Hyperoxia Following Resuscitation From Cardiac Arrest and In-Hospital Mortality

p<0.001

Hyperoxia vs normoxia

Hyperoxia vs hypoxia



Ventilation and oxygenation

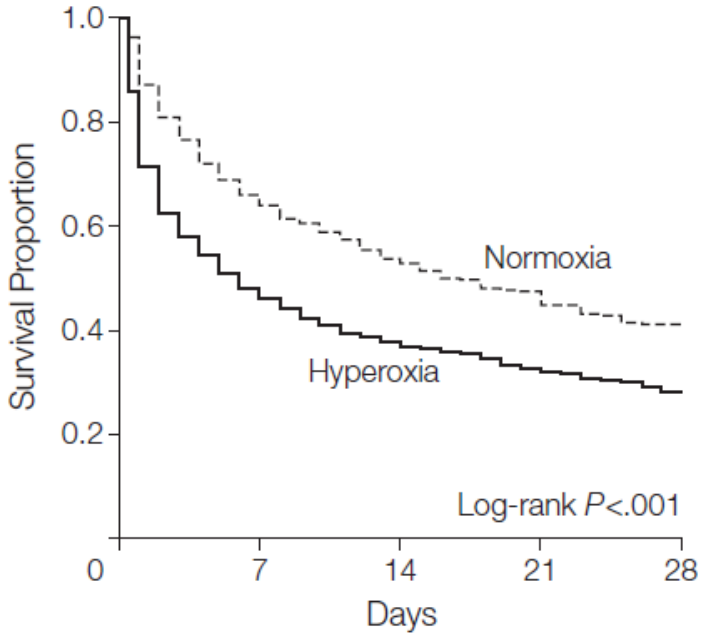
Association Between Arterial Hyperoxia Following Resuscitation From Cardiac Arrest and In-Hospital Mortality

Table 5. Multiple Logistic Regression Model With In-Hospital Mortality as the Dependent Variable[a]

Variable	OR (95% CI)	*P* Value
Age decile	1.1 (1.1-1.2)	<.001
Emergency department origin	1.5 (1.3-1.7)	<.001
Nonindependent functional status at admission	1.3 (1.1-1.4)	<.001
Chronic renal failure	1.6 (1.3-1.9)	<.001
Active chemotherapy	2.8 (1.8-4.6)	<.001
High heart rate in ICU[b]	1.9 (1.7-2.1)	<.001
Hypotension at ICU arrival[c]	2.1 (1.9-2.3)	<.001
Hypoxia exposure	1.3 (1.1-1.5)	.009
Hyperoxia exposure	1.8 (1.5-2.2)	<.001

[a] Event rates (mortality) for each variable and for the relevant reference group appear in eTable 2 at http://www.jama.com. The following variables were removed from the model because of nonsignificance: female sex, OR, 1.1 (95% CI, 1.0-1.2; *P*=.29); chronic respiratory disease, OR, 1.3 (95% CI, 1.0-1.6; *P*=.05); human immunodeficiency virus, OR, 1.9 (95% CI, 1.0-3.7; *P*=.06); and requiring inotropic therapy, OR, 1.1 (95% CI, 0.9-1.3; *P*=.19).
[b] Indicates the highest value for first 24 hours in the ICU (1=exceeds median; 0=median or lower).
[c] Defined as any systolic blood pressure of less than 90 mm Hg within 1 hour of ICU arrival.[14]

Figure. In-Hospital Death Between Hyperoxia and Normoxia



No. at risk

Normoxia	1171	514	236	129	83
Hyperoxia	1156	406	211	115	70

Ventilation and oxygenation

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

Association Between Postresuscitation Partial Pressure of Arterial Carbon Dioxide and Neurological Outcome in Patients With Post –Cardiac Arrest Syndrome

Brian W. Roberts, J. Hope Kilgannon, Michael E. Chansky, Neil Mittal, Jonathan Wooden and Stephen Trzeciak

Circulation. 2013;127:2107-2113; originally published online April 23, 2013;

193 patients non trauma cardiac arrest

Hypocapnia: Paco2 ≤30 mm Hg (27%)

Hypercapnia: Paco2 ≥50 mm Hg (33%)

Normocapnia: 30%

both hypocapnia and hypercapnia: 19%

Outcome: poor neurologic function at hospital discharge

Ventilation and oxygenation

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

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Association Between Postresuscitation Partial Pressure of Arterial Carbon Dioxide and Neurological Outcome in Patients With Post –Cardiac Arrest Syndrome

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Circulation. 2013;127:2107-2113; originally published online April 23, 2013;

Multivariate analysis odds for poor outcome:

- **Hypocapnia OR 2.43**

  (95% CI 1.04-5.65), p=0.040

- **Hypercapnia OR 2.20**

  (95% CI 1.03-4.71), p=0.042

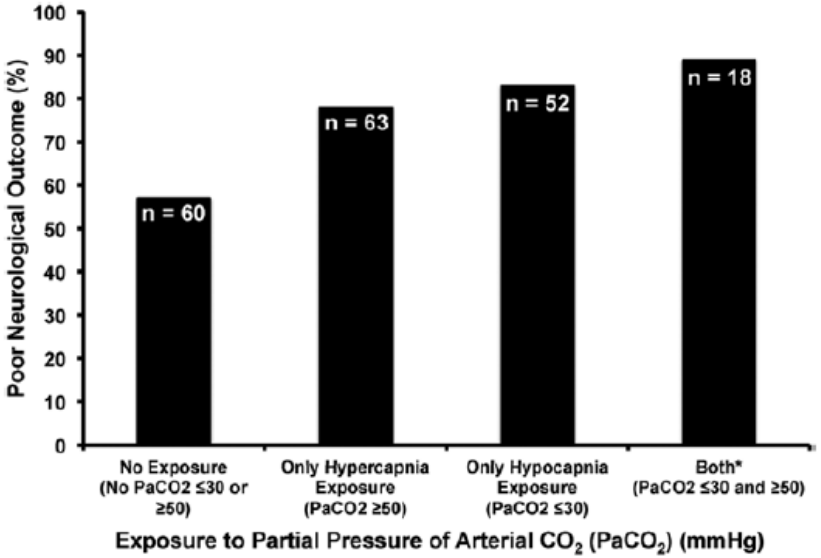

Figure. Proportion of patients with poor neurological function at hospital discharge (defined as a Cerebral Performance Category [CPC] ≥ 3) in relation to no exposure, only hypercapnia exposure, only hypocapnia exposure, and both hypocapnia and hypercapnia exposure during the first 24 hours after return of spontaneous circulation. $Paco_2$ indicates partial pressure of arterial CO_2.

Overview

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- **Reperfusion strategies**
- Metabolic control
- Mild therapeutic hypothermia
- Conclusions and recommendations

IMMEDIATE CORONARY ANGIOGRAPHY IN SURVIVORS OF OUT-OF-HOSPITAL CARDIAC ARREST

CHRISTIAN M. SPAULDING, M.D., LUC-MARIE JOLY, M.D., ALAIN ROSENBERG, M.D., MEHRAN MONCHI, M.D., SIMON N. WEBER, M.D., JEAN-FRANÇOIS A. DHAINAUT, M.D., PH.D., AND PIERRE CARLI, M.D.

(N Engl J Med 1997;336:1629-33.)

TABLE 4. RELATION BETWEEN ST-SEGMENT ELEVATION, CHEST PAIN BEFORE CARDIAC ARREST, AND RECENT CORONARY-ARTERY OCCLUSION IN THE 84 PATIENTS WHO UNDERWENT CORONARY ANGIOGRAPHY.*

VARIABLE	NO. OF PATIENTS	NO. WITH RECENT CORONARY-ARTERY OCCLUSION (%)
ST-segment elevation and chest pain		
Present	15	13 (87)
Absent	69	27 (39)
ST-segment elevation or chest pain		
Present	49	31 (63)
Absent	35	9 (26)

*ST-segment elevation was defined as an elevation of more than 1 mm in two contiguous leads.

Sucessful PTCA:

independent predictor of survival

OR 5.2; 95% CI 1.1 to 24.5

Original Articles

Immediate Percutaneous Coronary Intervention Is Associated With Better Survival After Out-of-Hospital Cardiac Arrest

Insights From the PROCAT (Parisian Region Out of Hospital Cardiac Arrest) Registry

Florence Dumas, MD; Alain Cariou, MD; Stéphane Manzo-Silberman, MD; David Grimaldi, MD; Benoît Vivien, MD; Julien Rosencher, MD; Jean-Philippe Empana, MD; Pierre Carli, MD; Jean-Paul Mira, MD; Xavier Jouven, MD; Christian Spaulding, MD

(Circ Cardiovasc Interv. 2010;3:200-207.)

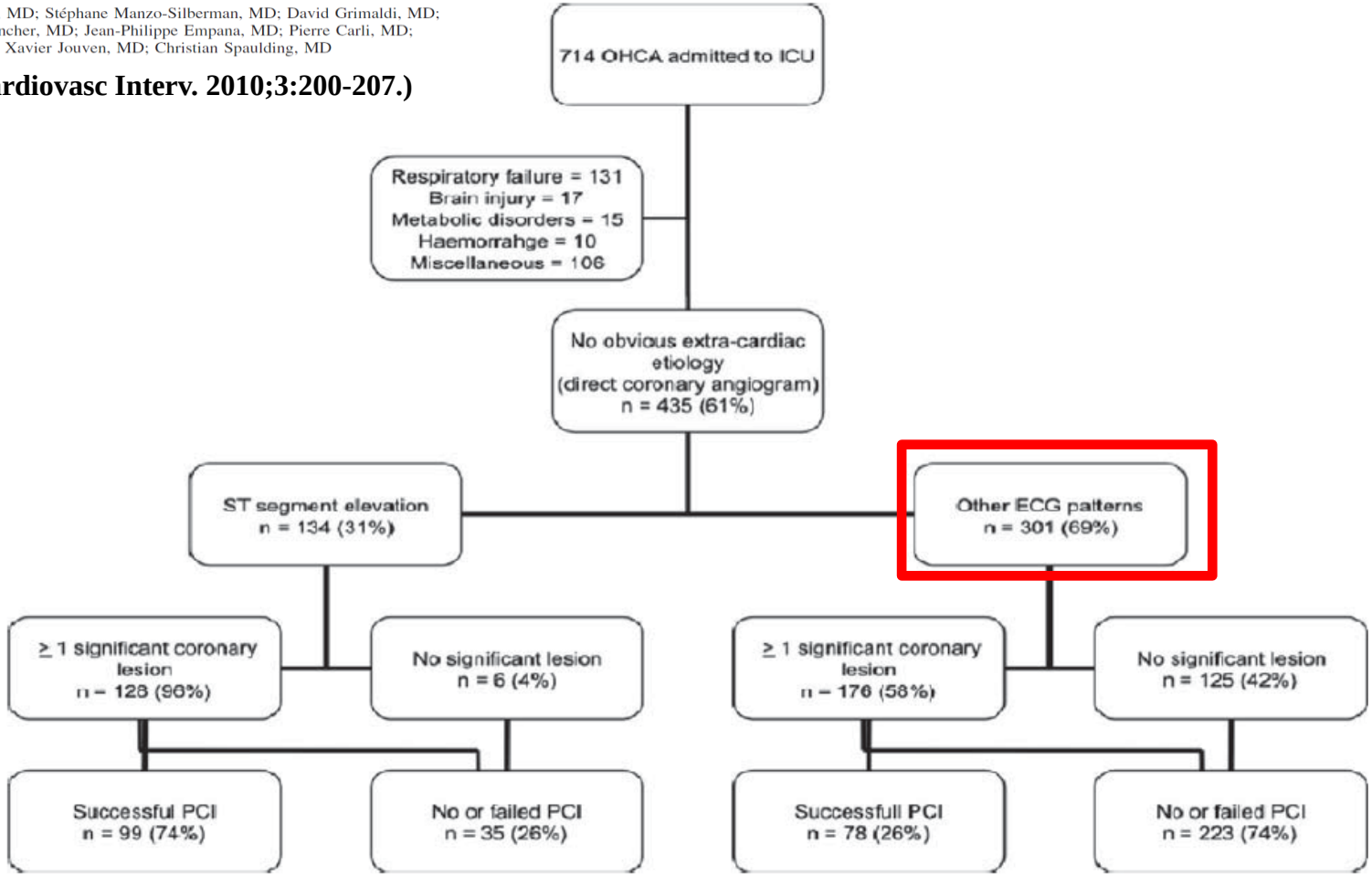

Figure 1. Patients post-ROSC admitted to the intensive care unit.

Original Articles

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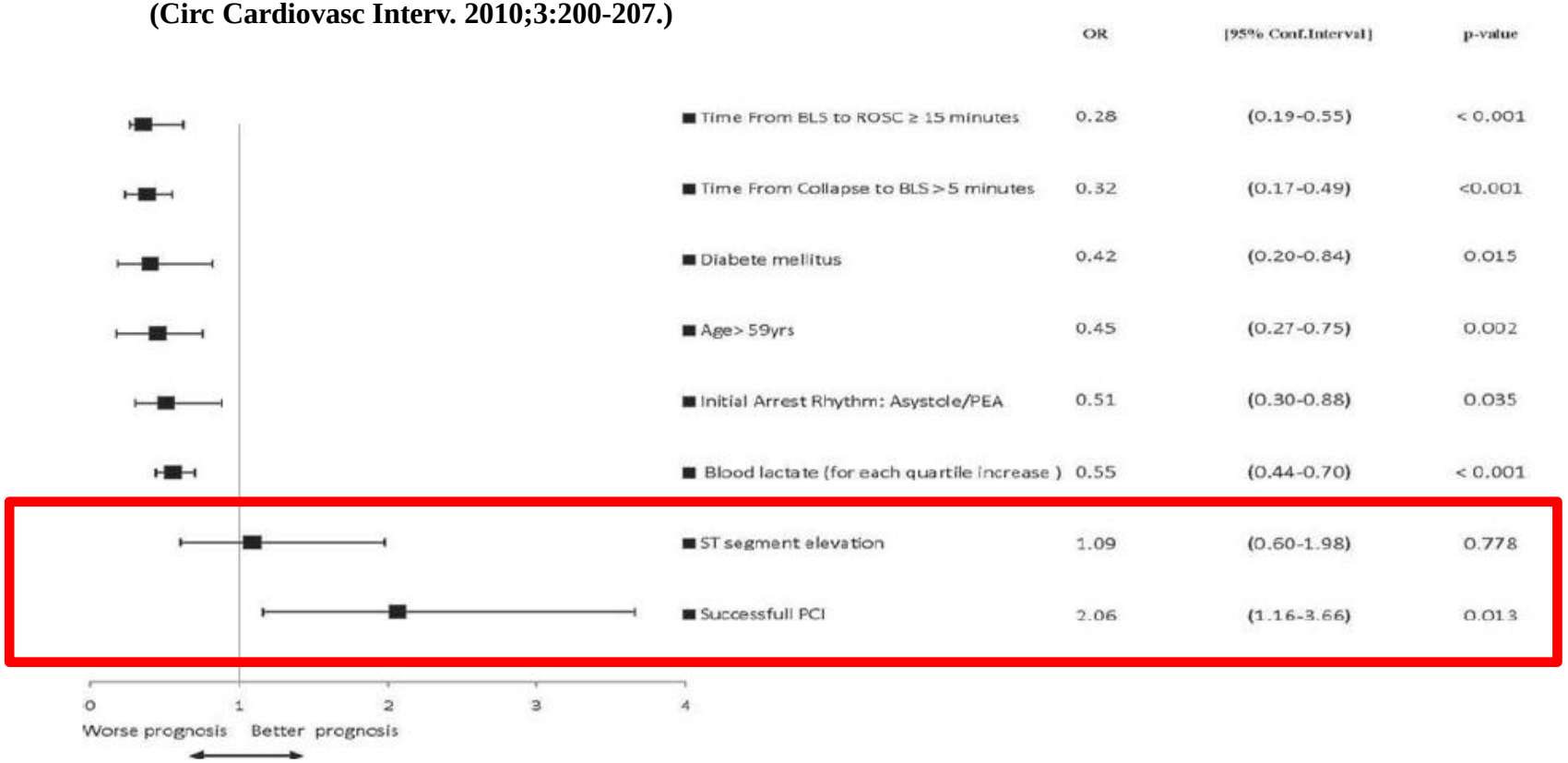


Figure 3. Multivariable logistic regression analysis of early predictors of survival in patients with OHCA without obvious extracardiac causes. PEA indicates pulseless electrical activity.

G Model
RESUS-5682; No. of Pages 8

ARTICLE IN PRESS

Resuscitation xxx (2013) xxx–xxx

Contents lists available at ScienceDirect

Resuscitation

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

Clinical Paper

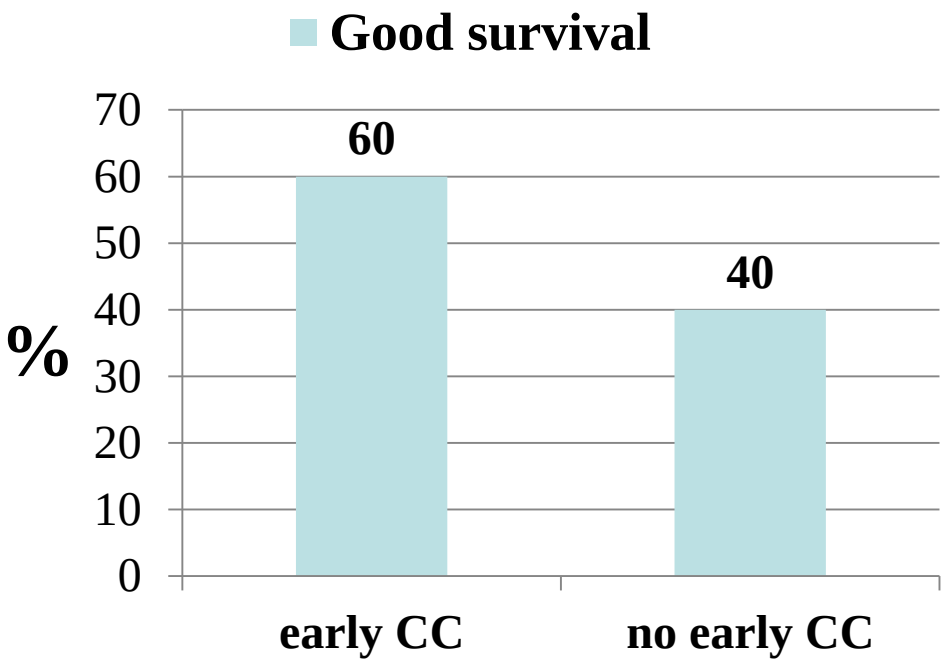
Early cardiac catheterization is associated with improved survival in comatose survivors of cardiac arrest without STEMI☆

Ryan D. Hollenbeck[a,*,1], John A. McPherson[a,1], Michael R. Mooney[b], Barbara T. Unger[b], Nainesh C. Patel[c], Paul W. McMullan Jr.[d], Chiu-Hsieh Hsu[e], David B. Seder[f], Karl B. Kern[g]

[a] Division of Cardiovascular Medicine, Vanderbilt University Medical Center, Nashville, TN, United States
[b] Minneapolis Heart Institute Foundation at Abbott Northwestern Hospital, Minneapolis, MN, United States
[c] Division of Cardiovascular Medicine, Lehigh Valley Hospital and Health Network, Allentown, PA, United States
[d] Department of Cardiology, Ochsner Medical Center, New Orleans, LA, United States
[e] Department of Epidemiology and Biostatistics, University of Arizona College of Public Health, Tucson, AZ, United States
[f] Department of Critical Care Services and Neuroscience Institute, Maine Medical Center, Portland, ME, United States
[g] Division of Cardiovascular Medicine, University of Arizona Medical Center, Tucson, AZ, United States

269 Patients after VF/VT CA and no STEMI

- **early cardiac catheterization (within 24 hours): n=122**
- **No early catheterization: n=147**



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Ryan D. Hollenbeck[a,*,1], John A. McPherson[a,1], Michael R. Mooney[b], Barbara T. Unger[b], Nainesh

[a] Division of C
[b] Minneapolis
[c] Division of C
[d] Department
[e] Department
[f] Department
[g] Division of C

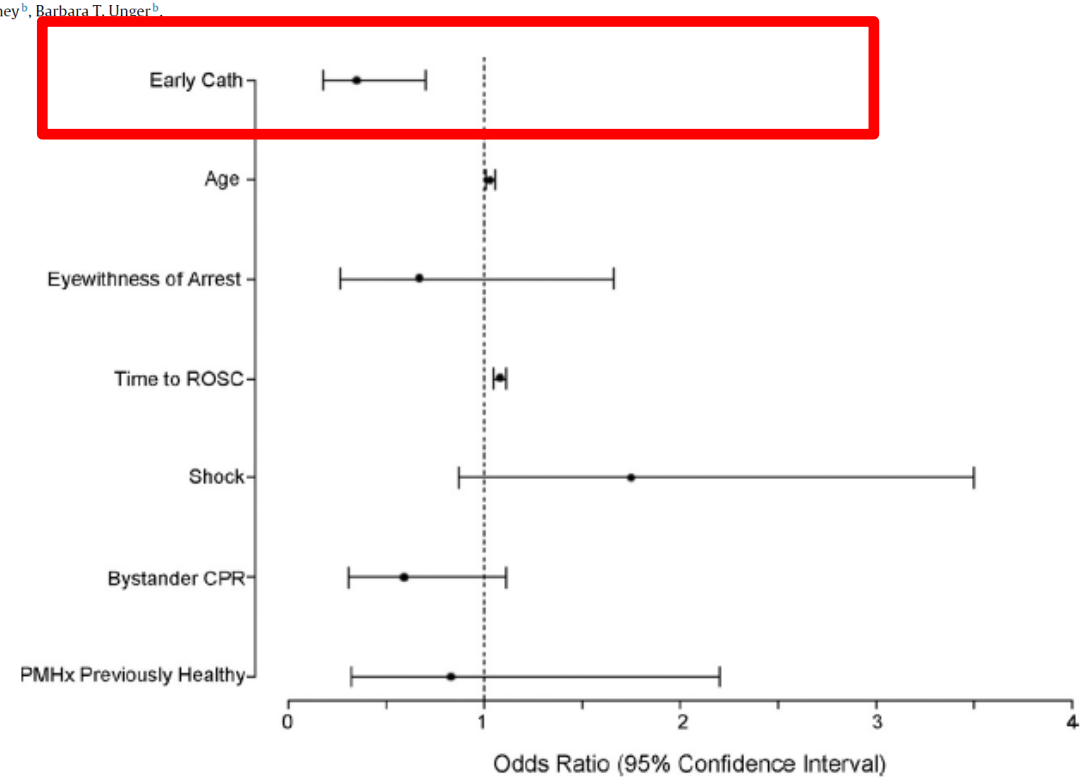

Fig. 2. Predictors of hospital mortality. Displays a multivariate logistic regression analysis examining predictors of in-hospital mortality. All patients who survived to hospital admission following cardiac arrest due to a ventricular arrhythmia and without ST elevation myocardial infarction on the postresuscitaiton electrocardiogram were included in the analysis ($n = 269$). The model adjusts for study site, age, bystander CPR, shock on admission, pre-arrest chronic medical conditions, eyewitness to arrest, and time to ROSC (minutes). Patients were considered to be previously healthy if they had no known chronic medical conditions prior to the arrest. Early cardiac catheterization (CC) was defined as CC performed either immediately upon hospital admission or during hypothermia treatment, which includes up to 24 hours following cardiac arrest. By definition, all patients who received early CC were comatose and their potential for neurologic recovery remained unknown at the time of CC. ROSC = return of spontaneous circulation; CPR = cardiopulmonary resuscitation; PMHx = past medical history.

Significance of arterial hypotension after resuscitation from cardiac arrest*

Stephen Trzeciak, MD, MPH; Alan E. Jones, MD; J. Hope Kilgannon, MD; Barry Milcarek, PhD; Krystal Hunter, MBA; Nathan I. Shapiro, MD, MPH; Steven M. Hollenberg, MD; R. Phillip Dellinger, MD; Joseph E. Parrillo, MD

(Crit Care Med 2009; 37:2895–2903)

8.736 patients, 120 ICUs US

Hypotension: one or more documented SBP <90 mmHg within 1 hr of ICU arrival

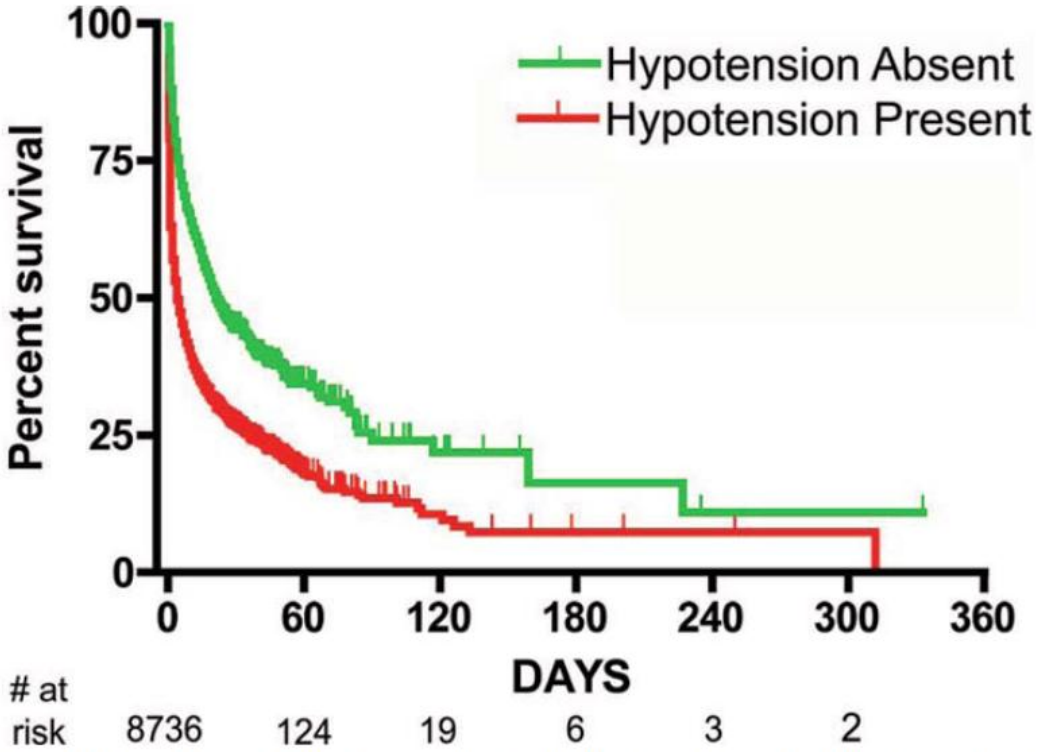

Figure 1. Kaplan-Meier survival curves for patients with Hypotension Present and Hypotension Absent after return of spontaneous circulation from cardiac arrest (with censoring). The survival fractions diverged significantly by log-rank test ($p < .001$).

Intensive Care Med (2013) 39:1981–1988
DOI 10.1007/s00134-013-3075-9

ORIGINAL ARTICLE

Marie E. Beylin
Sarah M. Perman
Benjamin S. Abella
Marion Leary
Frances S. Shofer
Anne V. Grossestreuer
David F. Gaieski

Higher mean arterial pressure with or without vasoactive agents is associated with increased survival and better neurological outcomes in comatose survivors of cardiac arrest

- **168 patients after CA and treated with mild hypothermia**
- **MAP at 1, 6, 12, 24 h after ROSC**

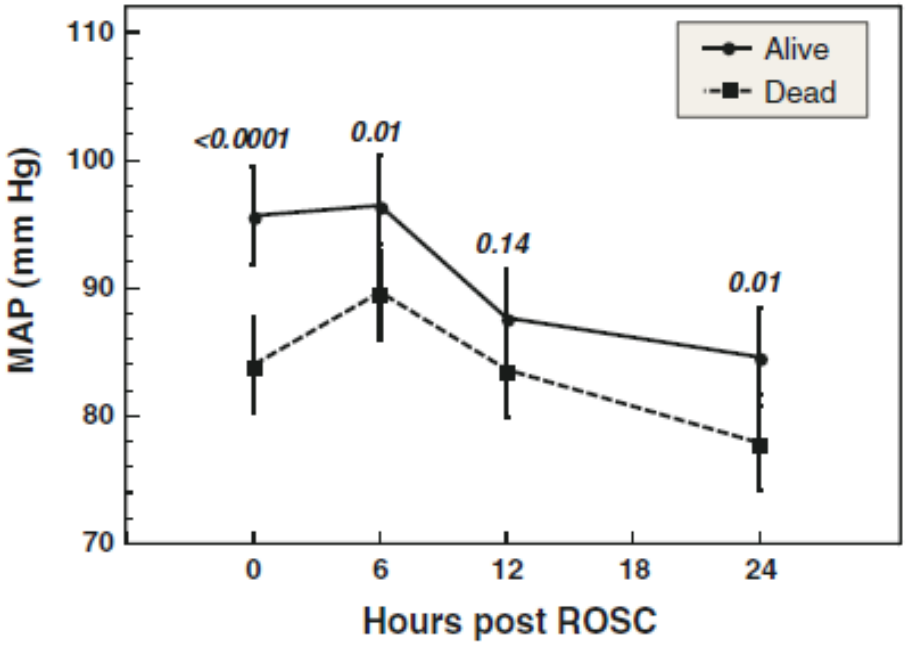

Fig. 3 Survivors have higher mean arterial pressure (MAP) than non-survivors at all time points except 12 h post-return of spontaneous circulation (ROSC)

Overview

- Introduction
- Ventilation and oxygenation strategies
- Reperfusion strategies
- **Metabolic control**
- Mild therapeutic hypothermia
- Conclusions and recommendations

Resuscitation (2008) 76, 214–220

available at www.sciencedirect.com

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

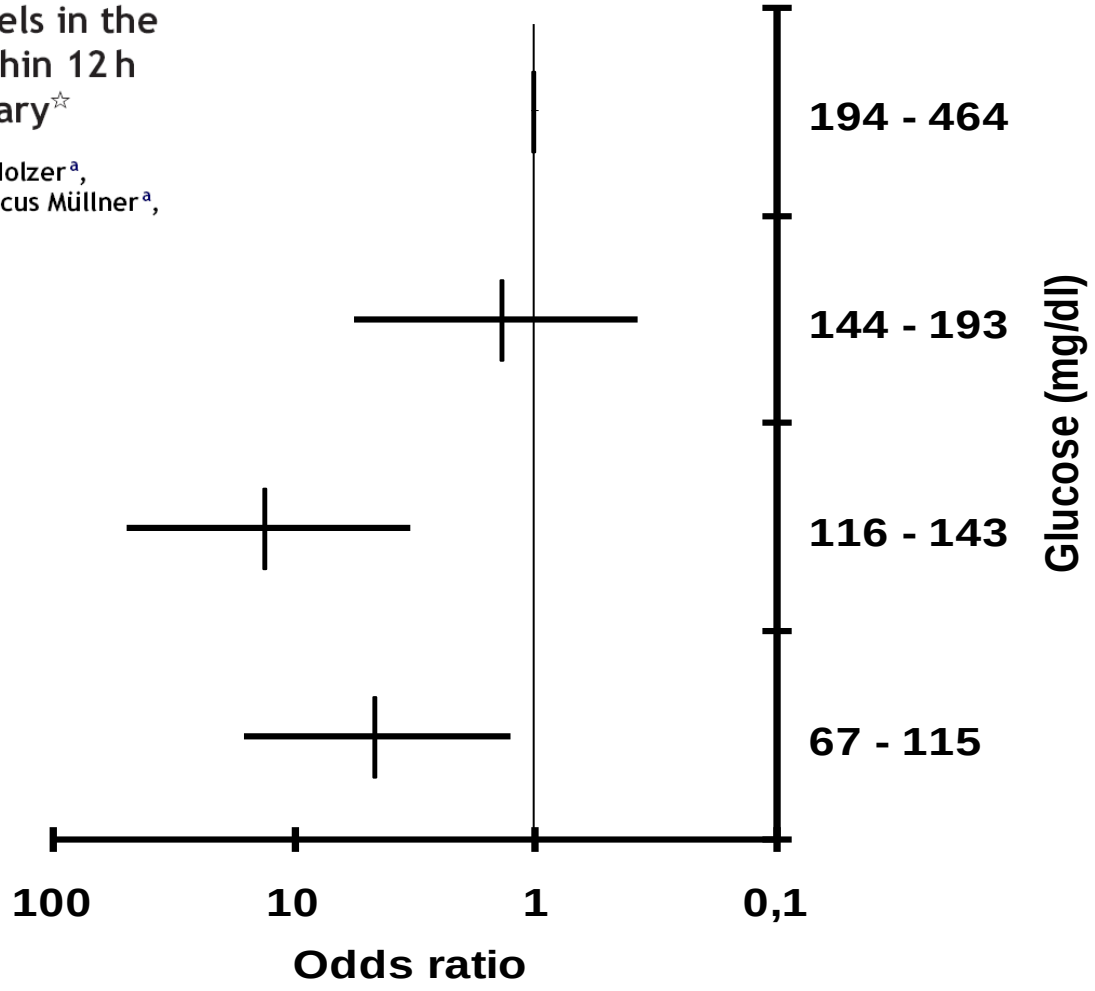
CLINICAL PAPER

Strict normoglycaemic blood glucose levels in the therapeutic management of patients within 12 h after cardiac arrest might not be necessary☆

Heidrun Losert[a], Fritz Sterz[a,*], Risto O. Roine[b], Michael Holzer[a], Patrick Martens[c], Erga Cerchiari[d], Marjaana Tiainen[b], Marcus Müllner[a], Anton N. Laggner[a], Harald Herkner[a], Martin G. Bischof[e]

234 patients OOHCA

Odds ratio of good neurological recovery after CA



Resuscitation 80 (2009) 624–630

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

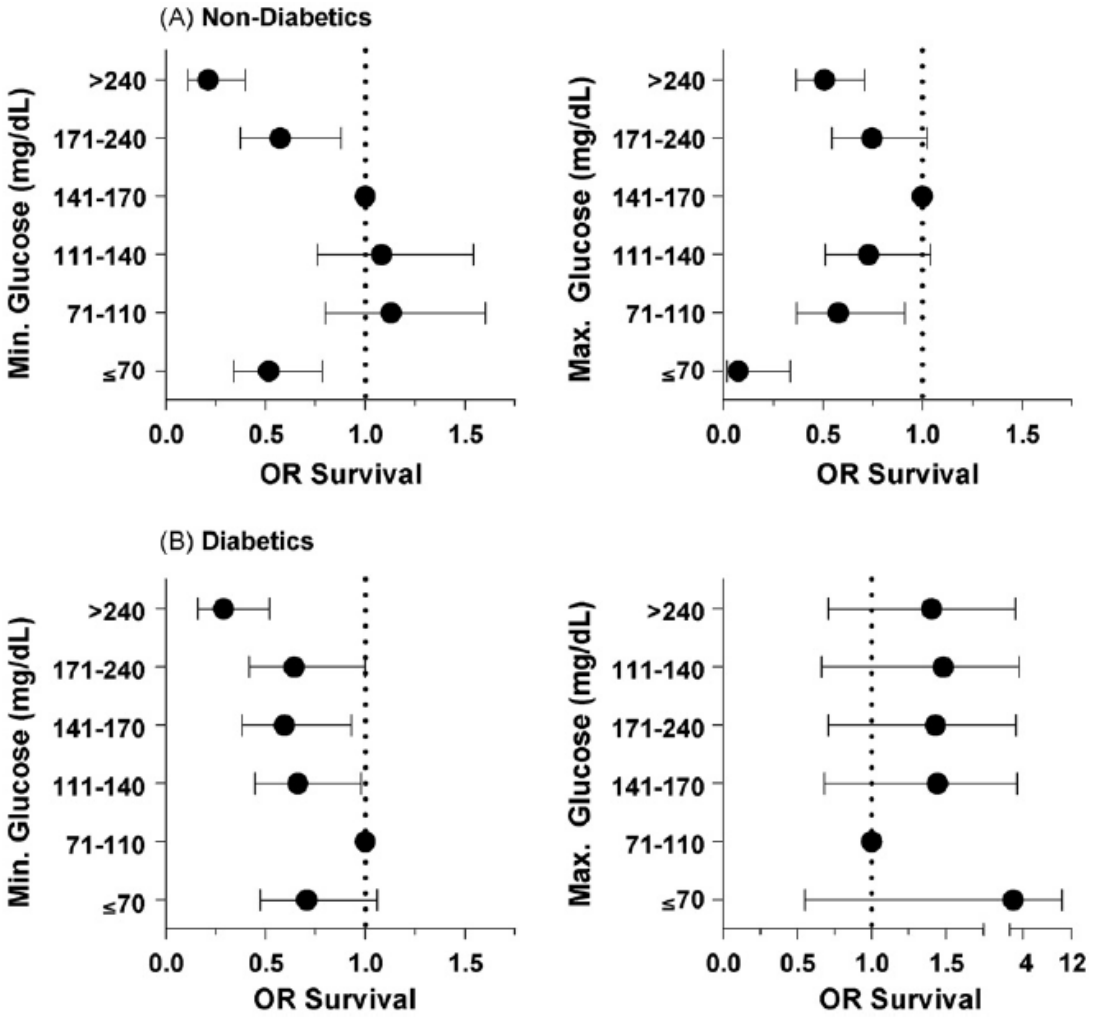
Derangements in blood glucose following initial resuscitation from in-hospital cardiac arrest: A report from the national registry of cardiopulmonary resuscitation☆

David G. Beiser[a,*,d], Gordon E. Carr[b,d], Dana P. Edelson[b,d], Mary Ann Peberdy[c,d], Terry L. Vanden Hoek[a,d]

[a] Section of Emergency Medicine, Department of Medicine, University of Chicago, Chicago, IL 60637, USA
[b] Section of Pulmonary and Critical Care Medicine, Department of Medicine, University of Chicago, Chicago, IL 60637, USA
[c] Division of Cardiology, Virginia Commonwealth University, Richmond, VA 23298, USA

17.800 adult IHCA

Odds ratio of survival after CA



Severe hypoglycemia in critically ill patients: Risk factors and outcomes*

James S. Krinsley, MD, FCCM, FCCP; Aarti Grover, MD

Crit Care Med 2007

… that even a single episode of severe hypoglycemia (< 40 mg/dl) was independently associated with *increased risk of mortality*.

Overview

- Introduction
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Scientific Program

May 15, 2014, Thursday – Hall A (Day 1)	
Objective is updating the current data of resuscitation by usage of modern literature related and discussing resuscitation witnessed by the family.	
14.30–16.00	**Resuscitation** **Chairs: Wilhelm Behringer, Levent Altıntop**
14:30–14:50	Up-to-date Resuscitation Strategies for Multi-Trauma Patients Victor Rodriguez, Venezuela
14:50–15:10	Thoracotomy in Emergency After Traumatic Cardiopulmonary Arrest Khaled Aljohani, Saudi Arabia
15:10–15:30	Management of Post Cardiac Arrest Syndrome Wilhelm Behringer, Austria
15:30–15:50	Hypothermic Resuscitation Jasmin Arrich, Austria

Overview

- Introduction
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Conclusions

- **Ventilation and oxygenation strategies:**
  - ***"… to maintain the arterial blood oxygen saturation in the range of 94–98%"***
  - ***"… it is reasonable to adjust ventilation to achieve normocarbia"***
- **Reperfusion strategies**
  - ***" … PCI for post-cardiac arrest patients with STEMI … and should be considered in all post-CA patients who are suspected of having coronary artery disease"***
  - **Avoid hypotension**
- **Metabolic control**
  - ***"… following ROSC blood glucose should be maintained at ≤10mmol/L (180mg/dl). Hypoglycaemia should be avoided."***
- **Mild therapeutic hypothermia**
  - **Next presentation**


One, two three, BREATHE
He's dead, Jim
Shared from facebook.com/georgehtake
Share your fun content with us every Friday at facebook.com/grammarly

Does the 5th link help?

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

Implementation of the Fifth Link of the Chain of Survival Concept for Out-of-Hospital Cardiac Arrest

Takashi Tagami, Kazuhiko Hirata, Toshiyuki Takeshige, Junichiroh Matsui, Makoto Takinami, Masataka Satake, Shuichi Satake, Tokuo Yui, Kunihiro Itabashi, Toshio Sakata, Ryoichi Tosa, Shigeki Kushimoto, Hiroyuki Yokota and Hisao Hirama

Circulation. 2012;126:589-597
doi: 10.1161/CIRCULATIONAHA.111.086173
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0009-7322. Online ISSN: 1524-4539

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Print ISSN: 0009-7322. Online ISSN: 1524-4539

- **before (01/2006–04/2008) - after (01/2009–12/2010) study**
- **Intensive postresuscitation care**
  - **appropriate hemodynamic**
  - **respiratory management**
  - **therapeutic hypothermia**
  - **PCI**
- **n = 1.482**

Does the 5th link help?

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

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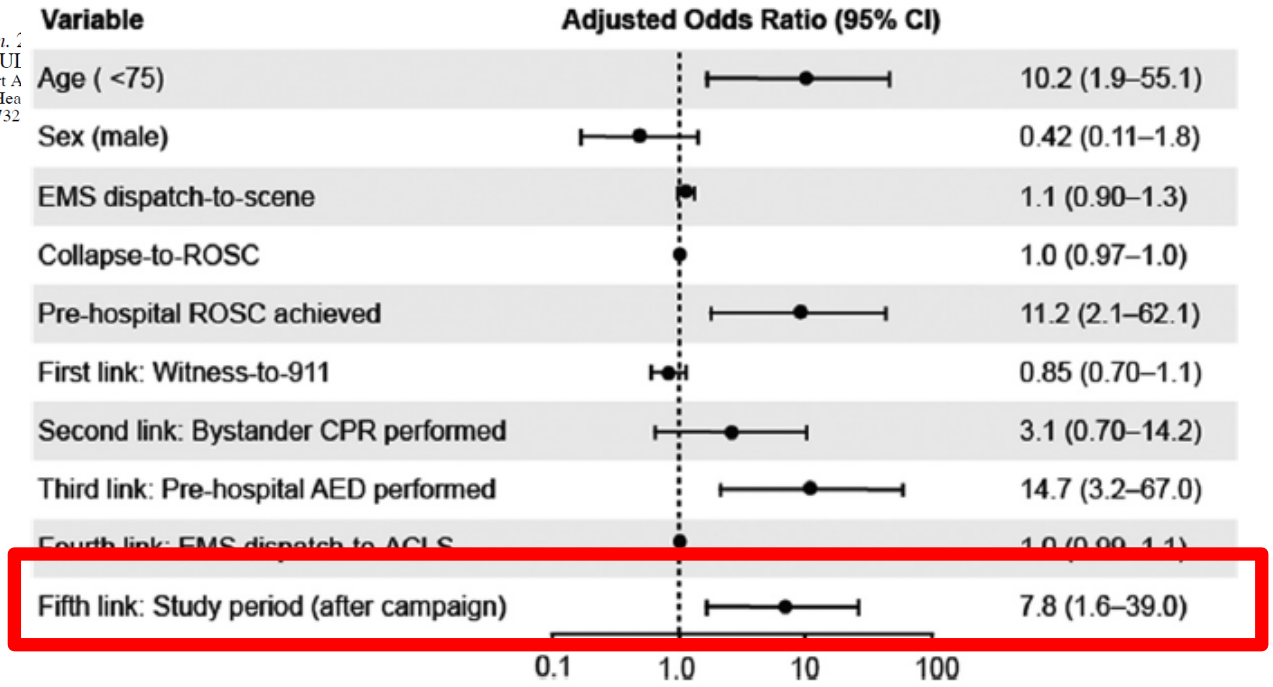
Circulation. 2
doi: 10.1161/CIRCUI
Circulation is published by the American Heart A

Print ISSN: 0009-732



Favorable neurologic outcome (1 mo CPC 1/2)

In which hospitals should we treat CA patients?

Resuscitation 80 (2009) 30–34

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

Inter-hospital variability in post-cardiac arrest mortality☆

Brendan G. Carr[a,b,c,d,e,*], Jeremy M. Kahn[d,e,f], Raina M. Merchant[a,b,c,d], Andrew A. Kramer[g], Robert W. Neumar[b,c]

USA: 4.674 patients from 39 hospitals

In which hospitals should we treat CA patients?

Resuscitation 80 (2009) 30–34

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Mortality ranging from 46% to 68%

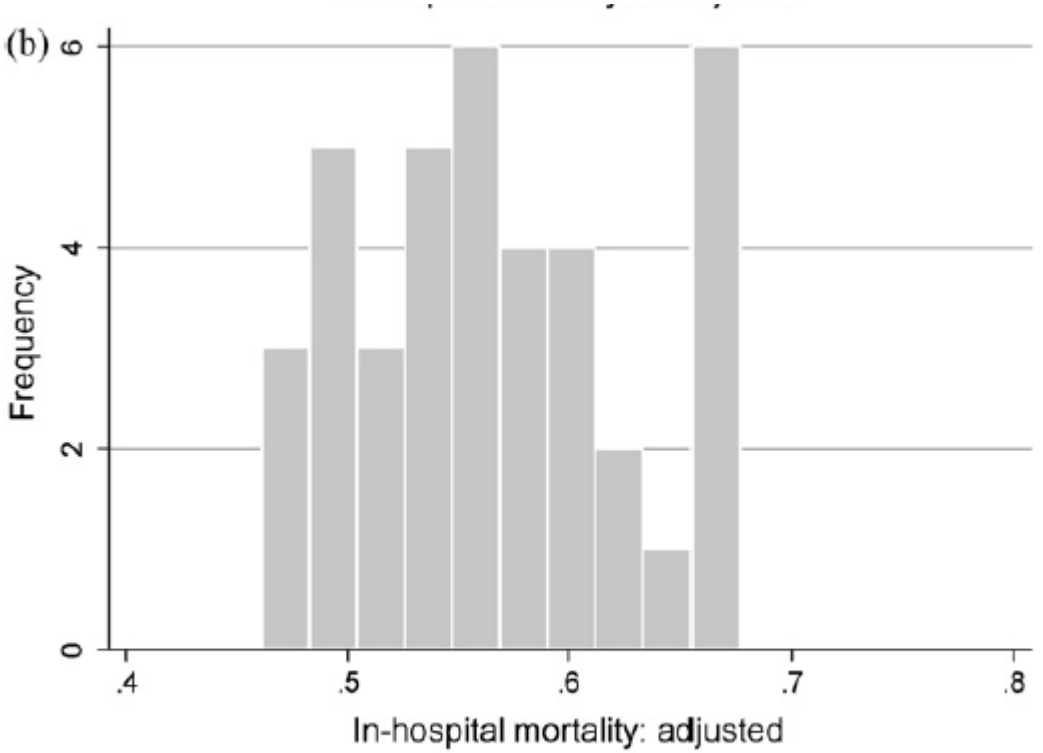

Figure 1. Frequency of in-hospital mortality among APACHE Hospitals: (a) unadjusted rates; (b) rates adjusted for age, severity of illness and ventilation status.

In which hospitals should we treat CA patients?

Resuscitation 80 (2009) 30–34

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

Inter-hospital variability in post-cardiac arrest mortality☆

Brendan G. Carr[a,b,c,d,e,*], Jeremy M. Kahn[d,e,f], Raina M. Merchant[a,b,c,d], Andrew A. Kramer[g], Robert W. Neumar[b,c]

Mortality ranging from 46% to 68%

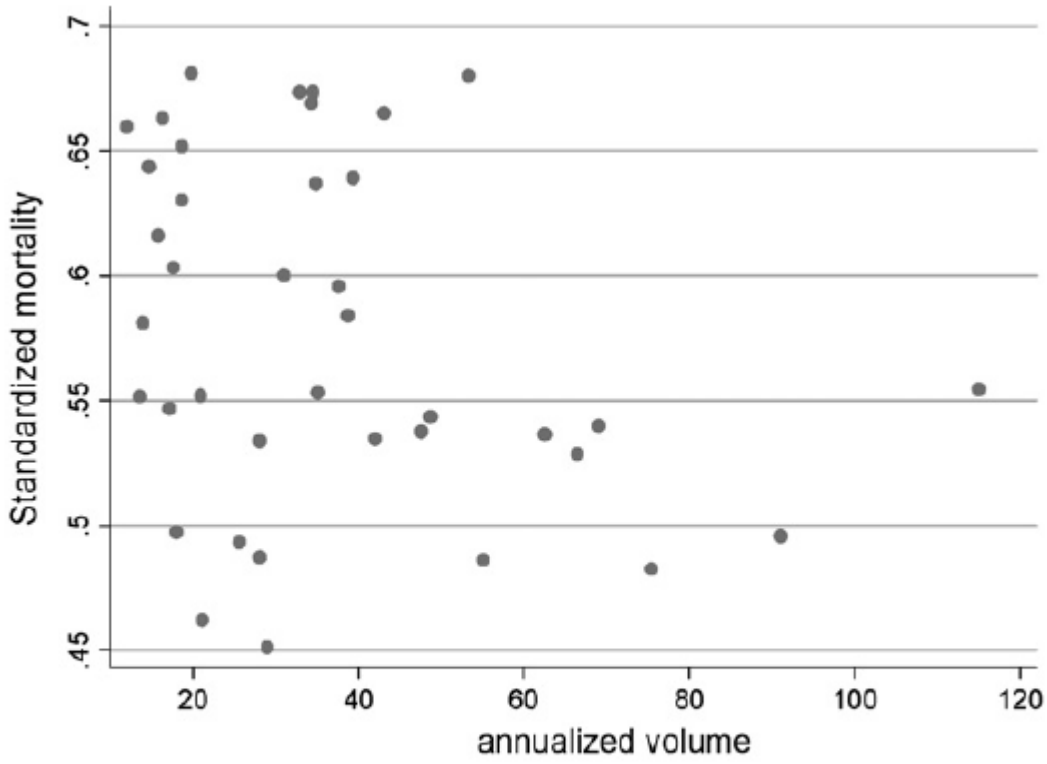

Figure 2. In-hospital mortality rate (mortality rates standardized by age, acute physiology score, Glasgow Coma Scale on admission and ventilation status) vs. annualized post-arrest volume: scatter plot of APACHE ICUs.

In which hospitals should we treat CA patients?

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Resuscitation 43 (2000) 201–211

RESUSCITATION

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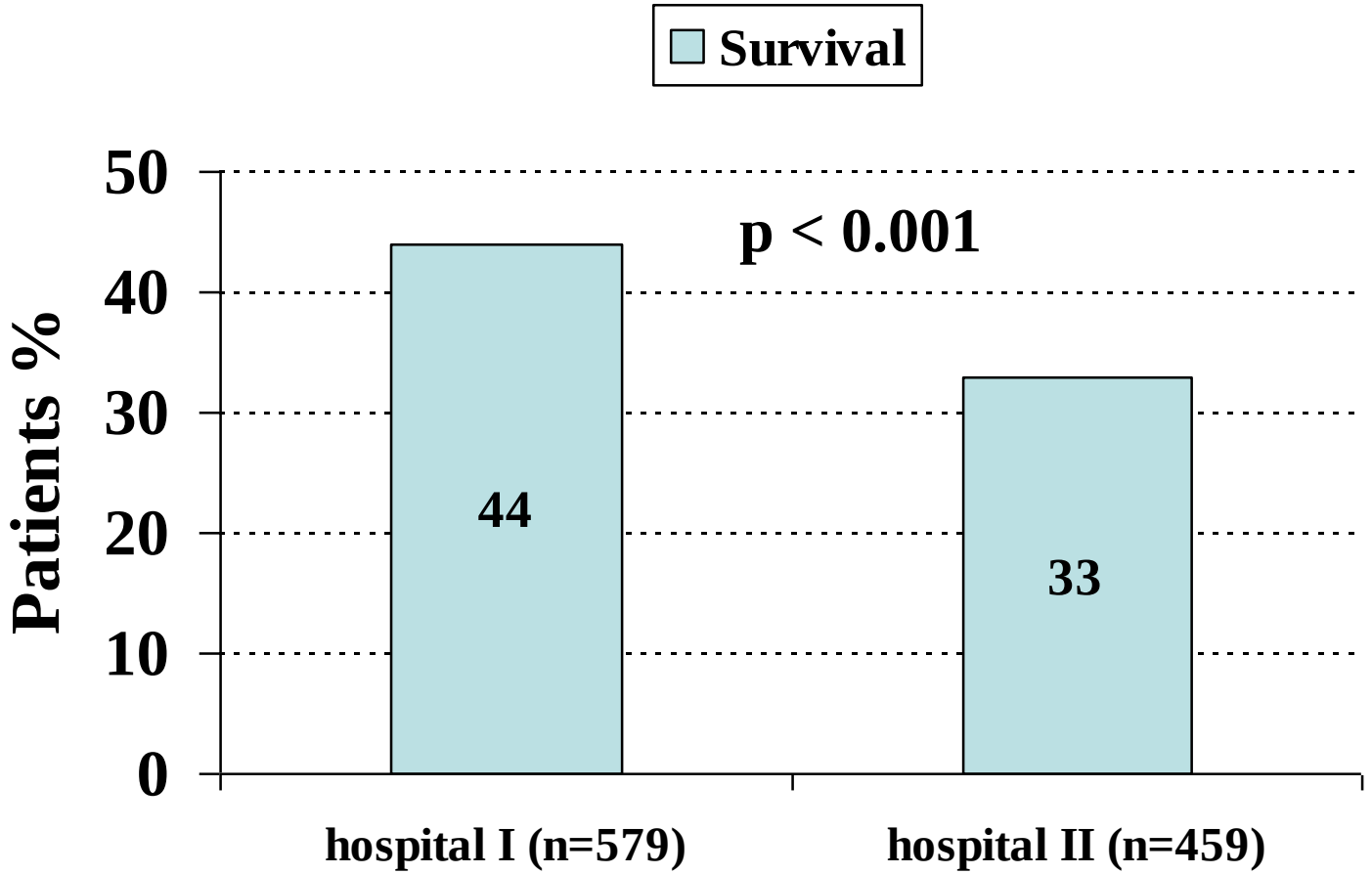
Is hospital care of major importance for outcome after out-of-hospital cardiac arrest? Experience acquired from patients with out-of-hospital cardiac arrest resuscitated by the same Emergency Medical Service and admitted to one of two hospitals over a 16-year period in the municipality of Göteborg

Johan Engdahl *, Putte Abrahamsson, Angela Bång, Jonny Lindqvist, Thomas Karlsson, Johan Herlitz

Division of Cardiology, Sahlgrenska University Hospital, SE-413 435, Göteborg, Sweden

Received 14 June 1999; received in revised form 8 November 1999; accepted 18 November 1999

In which hospitals should we treat CA patients?



In which hospitals should we treat CA patients?

Critical Care

CRITICAL CARE

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Choice of hospital after out-of-hospital cardiac arrest - a decision with far reaching consequences - a study in a large German city

Critical Care 2012, **16**:R164 doi:10.1186/cc11516

Jan Wnent (jan.wnent@uksh.de)
Stephan Seewald (seewald@reanimationsregister.de)
Matthias Heringlake (heringlake@t-online.de)
Hans Lemke (hlemke@stadtdo.de)
Kirk Brauer (kirk.brauer@uksh.de)
Rolf Lefering (Rolf.Lefering@uni-wh.de)
Matthias Fischer (Matthias.Fischer@kae.de)
Tanja Jantzen (prof.tanja.jantzen@t-online.de)
Berthold Bein (bein@anaesthesie.uni-kiel.de)
Martin Messelken (M.Messelken@kae.de)
Jan-Thorsten Grasner (graesner@reanimationsregister.de)

Dortmund

with PCI (n=170)

w/o PCI (n=264)

In which hospitals should we treat CA patients?

Critical Care

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Table 3: Result of binary regression analysis on the influence of admitting hospital on frequency of alive discharges and discharged with good neurological status

	Discharged alive		Hospital discharged with good neurological status	
	OR (95% CI)	**P value**	**OR (95% CI)**	**P value**
Hospital with PCI-capability (Group 2)	2.39 (1.33-4.28)	0.004	3.14 (1.51-6.56)	0.002
Coronary angiography	4.57 (2.20-9.50)	p<0.001	6.16 (3.03-12.55)	p<0.001
Therapeutic hypothermia	5.31 (1.91-14.77)	0.001	3.11 (1.26-7.69)	0.014
Presenting rhythm – Asystole	0.46 (0.26-0.82)	0.008	-	-
Not shown in equation	Gender, neurological status prior collapse, age		Presenting rhythm, age, bystander CPR	

CPR, cardiopulmonary resuscitation; PCI, percutaneous coronary intervention

Conclusion III

Implementation of

cardiac arrest centres!!!!!