# Pitfalls in management of post cardiac arrest


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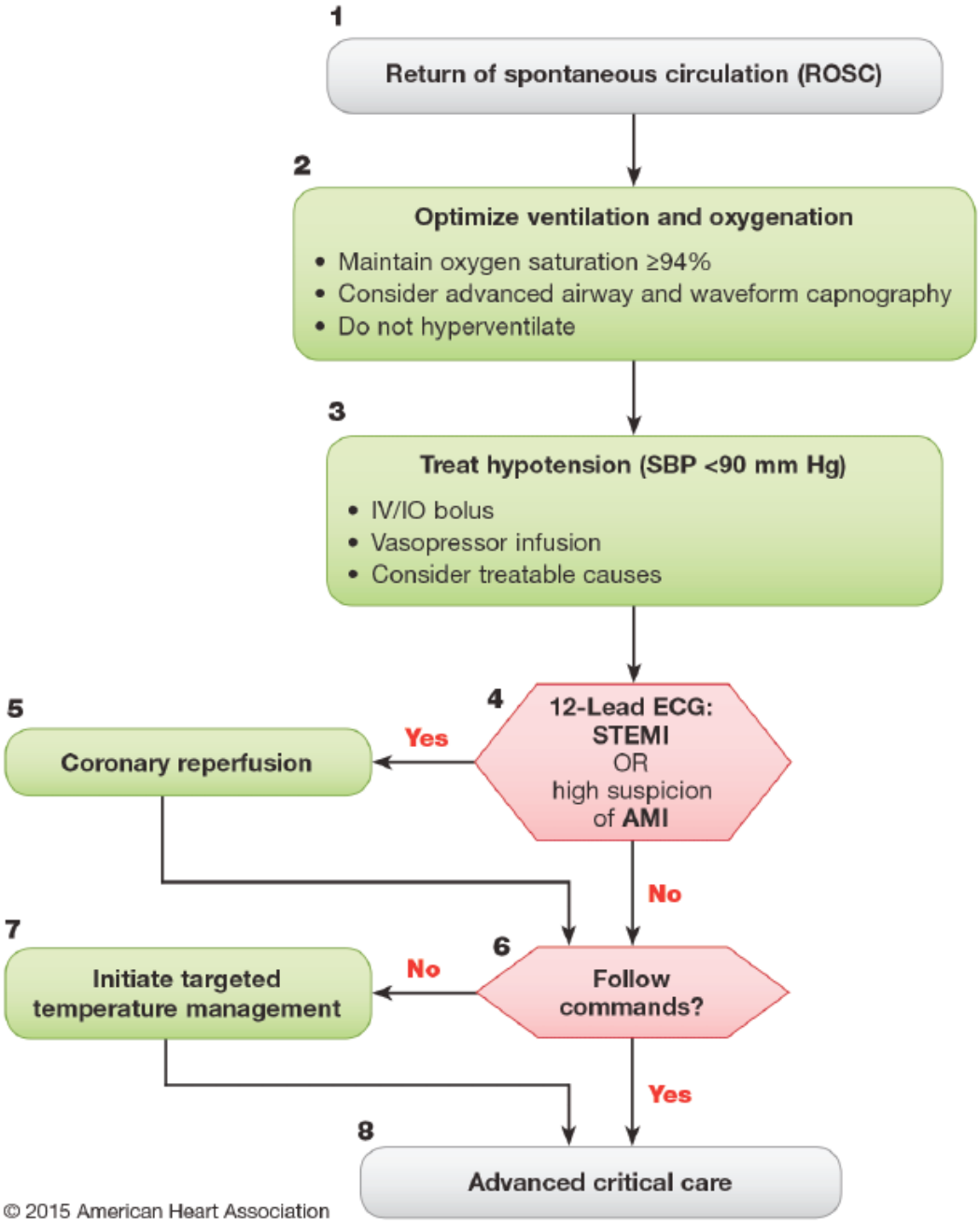
# Adult Immediate Post–Cardiac Arrest Care Algorithm—2015 Update






## Doses/Details

**Ventilation/oxygenation:**
Avoid excessive ventilation. Start at 10 breaths/min and titrate to target $P_{ETCO_2}$ of 35-40 mm Hg.
When feasible, titrate $F_{IO_2}$ to minimum necessary to achieve $Spo_2$ ≥94%.

**IV bolus:**
Approximately 1-2 L normal saline or lactated Ringer's

**Epinephrine IV infusion:**
0.1-0.5 mcg/kg per minute (in 70-kg adult: 7-35 mcg per minute)

**Dopamine IV infusion:**
5-10 mcg/kg per minute

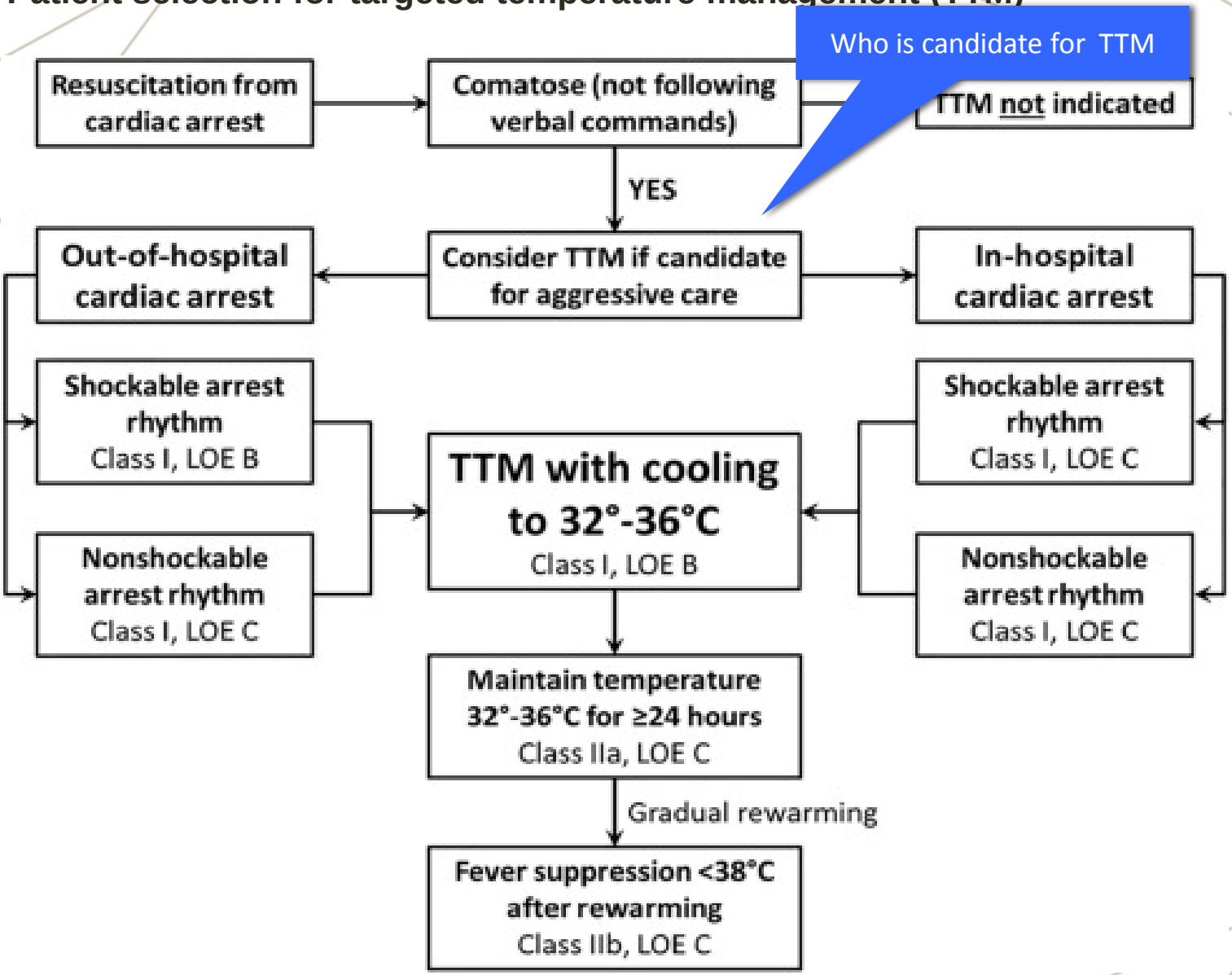
**Norepinephrine IV infusion:**
0.1-0.5 mcg/kg per minute (in 70-kg adult: 7-35 mcg per minute)

## Reversible Causes

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

# Targeted temperature management

# Patient selection for targeted temperature management (TTM)




Jacob C. Jentzer, Casey M. Clements, Joseph G. Murphy, R. Scott Wright **Recent Developments in the Management of Patients Resuscitated From Cardiac Arrest ☆ ☆☆**

Journal of Critical Care, 2017, Available online 16 February 2017 http://dx.doi.org/10.1016/j.jcrc.2017.02.011

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VOLUME 346 FEBRUARY 21, 2002 NUMBER 8

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

THE HYPOTHERMIA AFTER CARDIAC ARREST STUDY GROUP*

In patients who have been successfully resuscitated after cardiac arrest due to ventricular fibrillation, therapeutic mild hypothermia increased the rate of a favorable neurologic outcome and reduced mortality.

# IHCA

**Table 1. Nonrandomized Comparison of Therapeutic Hypothermia for In-Hospital Cardiac Arrest**

| | | | | Patients (n) | | Hospital Survival % | | Good Neuro Outcomes % | |
|---|---|---|---|---|---|---|---|---|---|
| Author | Year | Reference | Study Type | TH | C | TH | C | TH | C |
| Arrich | 2007 | 50 | Multicenter observational European registry | 43 | 59 | 39 | 60 | 28 | 29 |
| Rittenberger | 2004 | 51 | Retrospective observational Univ. of Pitt | 13 | 27 | 14 | 14 | 8 | 7 |
| Kony | 2012 | 52 | Retrospective historic Beth Israel | 17 | 16 | 29 | 31 | 24 | 31 |
| Nichol | 2013 | 53 | Multicenter prospective observational USA | 214 | 8102 | 27.1 | 31.0 | 18.7 | 20.1 |

Abbreviations: C, control group (did not receive therapeutic hypothermia); n, number; TH, received therapeutic hypothermia.

# Non shockable rhythm

**Table 2. Effect of Therapeutic Hypothermia on Patients After Cardiac Arrest Associated With Nonshockable Rhythms**

| | | | Study | | | | | # of Patients | | Hospital Survival (%)* | | | Good Neuro Outcome (%)† | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Author | Year | Ref | Type of Control | Design | Characteristics | Site & Years of Study | Location of Arrest | TH | C | TC | C | SS | TC | C | SS |
| Hachimi-Idrissi | 2001 | 69 | RCT | P | Single Center | Before 2001 Belgium | OOH | 16 | 14 | 19‡ | 7‡ | NS§ | 12.5 | 0 | NS§ |
| Kim | 2007 | 70 | RCT | P | Single Center Pre Hospital Cooling | 2004-2006 Seattle | OOH | 34 | 40 | 6 | 20 | NS§ | 6 | 18 | NS§ |
| Arrich | 2007 | 50 | Conc | P | Multicenter (19) Euro Registry | 2003-2005 Europe | Both | 124 | 73 | 36 | 19 | S | 28 | 19 | NS |
| Bro-Jeppesen | 2009 | 71 | Hx | P | Single Center for City | 2004-2006 *v* 2002-2004 Copenhagen | OOH | 13 | 21 | 54 | 24 | NS§ | — | — | — |
| Don | 2009 | 72 | Hx | R | Single Center | 2000-2004 Seattle | OOH | 122 | 191 | 21 | 19 | NS | 11 | 9 | NS |
| Dumas | 2011 | 48 | Hx | P | Single Center | 2000-2009 Paris | OOH | 261 | 176 | — | — | — | 15 | 17 | NS |
| Lindner | 2013 | 73 | Conc | P | 3 Hospitals | 2004-2008 Norway | OOH | 143 | 120 | 17 | 9 | NS | 14 | 8 | NS |
| Lundbye | 2012 | 74 | Hx | R | Single Center | 2007-2010 *v* 2004-2007 USA | Both | 52 | 48 | 38 | 19 | S§ | 29 | 13 | S |
| Oddo | 2006 | 75 | Hx | R | Single Center | 2002-2004 *v* 1999-2002 Switzerland | OOH | 12 | 11 | 17 | 9 | NS§ | 17 | 0 | NS |
| Rittenberger | 2008 | 51 | Conc | R | Single Center | 2005-2007 USA | Both | 60 | 60 | 15 | 17 | NS | 8 | 10 | NS |
| Storm | 2012 | 76 | Hx | P | Single Center | 2007-2010 *v* 2002-2007 Berlin | OOH | 87 | 88 | 41 | 37 | NS§ | 27.5 | 18.2 | NS |
| Testori | 2011 | 39 | Conc | R | Single Center | 1992-2009 Vienna | OOH | 135 | 239 | 39‡ | 25‡ | S | 35‡ | 23‡ | S |
| Vaahersalo | 2013 | 77 | Conc | P | Multi-Center (21) | 2010-2011 Finland | OOH | 70 | 153 | 37 | 31 | NS§ | 19‖ | 16‖ | NS |
| Whitfield | 2009 | 78 | Conc | R | Single Center | 2001-2007 Australia | OOH | 15 | 13 | ¶ | ¶ | NS | ¶ | ¶ | NS |

Abbreviations: both, OOH and in-hospital; C, controls (ie, no TH); Conc, concurrent; Hx, historical; NS, not significant; OOH, out-of-hospital; P, prospective; R, retrospective; RCT, randomized control trial; S, significant; SS, statistical significance; TH, therapeutic hypothermia.

* Survival at time of hospital discharge unless otherwise stated in comments.

† At hospital discharge unless otherwise noted in comments.

‡ Outcome at 6 months.

§ Per Fisher's exact test by author of this essay.

‖ Outcome at 1 year.

¶ Raw data not in primary reference but authors stated that these outcomes were not different in the 2 groups.

PLOS ONE

RESEARCH ARTICLE

# Outcomes of Adult In-Hospital Cardiac Arrest Treated with Targeted Temperature Management: A Retrospective Cohort Study

**Chih-Hung Wang[1,2☯], Chien-Hua Huang[1☯], Wei-Tien Chang[1], Min-Shan Tsai[1], Ping-Hsun Yu[3], Yen-Wen Wu[4,5,6], Wen-Jone Chen[1,7]***

**1** Department of Emergency Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan, **2** Graduate Institute of Clinical Medicine, College of Medicine, National
ment of Emergency Medicine, Taipei Hospital, Ministry of Health
partments of Internal Medicine and Nuclear Medicine, National
wan University College of Medicine, Taipei, Taiwan,

## Methods

We conducted a retrospective observational study in a single medical centre. We included adult patients suffering IHCA betwee
regression analysis to evaluate assoc
outcomes.

## Results

We included a total of 678 patients in
Most (81.1%) patients met at least on
patients survived to hospital discharg
able neurological status at discharge.
neurological outcome (OR: 3.74, 95%
but it was not associated with survival
in the emergency department was po
8.40–67.64; *p* value < 0.001) and having vasopressors in place at the time of arrest was inversely associated with TTM use (OR: 0.08, 95% CI: 0.004–0.42; *p*-value = 0.02).

## Conclusion

TTM might be associated with favourable neurological outcome of IHCA patients, irrespective of arrest rhythms. The prevalence of proposed exclusion criteria for TTM was high among IHCA patients, but these factors did not influence the use of TTM in clinical practice or neurological outcomes after IHCA.

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Published online 2015 Sep 1. doi: 10.7860/JCDR/2015/14918.6491
PMCID: PMC4606266

# Therapeutic Hypothermia after Prolonged Cardiac Arrest: Case Report with Review of Literature

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## Abstract

Go to:

Patients who survive cardiac arrest often develop severe neurological dysfunction due to the hypoxic brain injury and reperfusion induced cell death. Therapeutic hypothermia (TH) has become a standard therapy of cerebral protection following the successful return of spontaneous circulation in patients of out-of-hospital cardiac arrest, according to American heart association guidelines. This is a case report of a 30-year-old patient who developed in-hospital cardiac arrest and was revived after prolonged cardiopulmonary resuscitation (CPR) and also required primary angioplasty. TH was then established with local measures for 24 hours for cerebral protection. The patient was gradually and successfully weaned off from ventilator with no neurological impairment. There is an increasing evidence of TH and its protective mechanisms in patients with non-shockable arrest rhythms with particular emphasis on neurological outcomes. This article emphasizes the role of TH in every successful CPR irrespective of the cardiac rhythm.

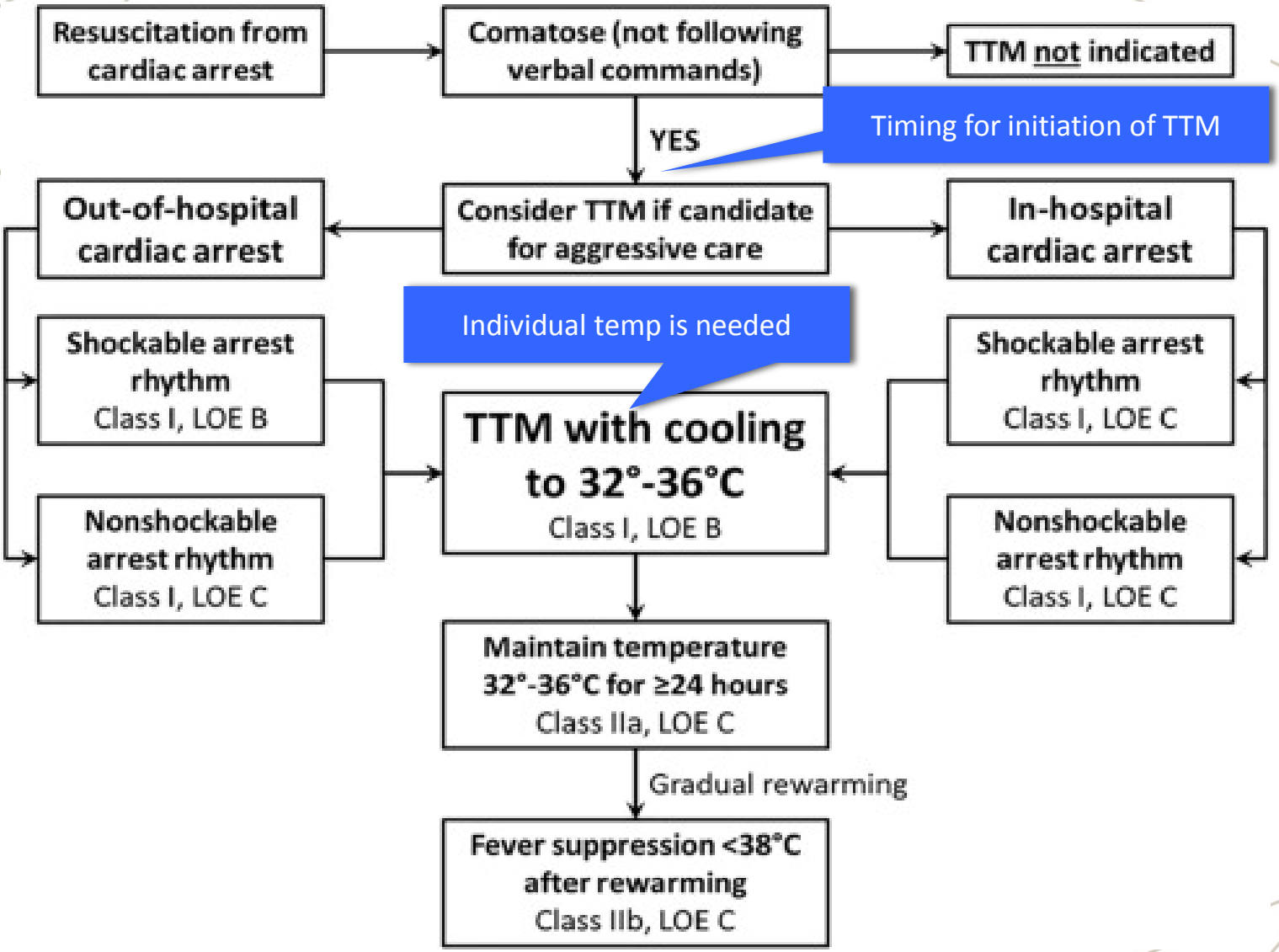
**Keywords:** Asystole, Cardiopulmonary resuscitation, Neurological outcome, Return of spontaneous circulation


J Clin Diagn Res

# Good candidate for TTM post cardiac arrest tend to get better result

- Shockable rhythm OHCA ( data from HACA 2002)
- Young age
- ACS caused cardiac arrest with successful PCI
- Short CPR time, Short time to begin CPR
- Less co-morbidities
- Witness arrest with bystander CPR
- **Data TTM in IHCA is not RCT outcome depend on other prognostic factors**

# Patient selection for targeted temperature management (TTM)




Jacob C. Jentzer, Casey M. Clements, Joseph G. Murphy, R. Scott Wright **Recent Developments in the Management of Patients Resuscitated From Cardiac Arrest ☆ ☆☆**

Journal of Critical Care, 2017, Available online 16 February 2017 http://dx.doi.org/10.1016/j.jcrc.2017.02.011

# Cardiac Arrest

## Pilot Trial Comparing 2 Levels of Target Temperature

Esteban Lopez-de-Sa, MD, FESC; Juan R. Rey, MD; Eduardo Armada, MD; Pablo Salinas, MD; Ana Viana-Tejedor, MD; Sandra Espinosa-Garcia, MD; Mercedes Martinez-Moreno, MD; Ervigio Corral, MD; Jose Lopez-Sendon, MD, PhD, FESC

***Background***—It is recommended that comatose survivors of out-of-hospital cardiac arrest should be cooled to 32° to 34°C for 12 to 24 hours. However, the optimal level of cooling is unknown. The aim of this pilot study was to obtain initial data on the effect of different levels of hypothermia. We hypothesized that deeper temperatures will be associated with better survival and neurological outcome.

***Methods and Results***—Patients were eligible if they had a witnessed out-of-hospital cardiac arrest from March 2008 to August 2011. Target temperature was randomly assigned to 32°C or 34°C. Enrollment was stratified on the basis of the initial rhythm as shockable or asystole. The target temperature was maintained during 24 hours followed by 12 to 24 hours of controlled rewarming. The primary outcome was survival free from severe dependence (Barthel Index score ≥60 points) at 6 months. Thirty-six patients were enrolled in the trial (26 shockable rhythm, 10 asystole), with 18 assigned to 34°C and 18 to 32°C. Eight of 18 patients in the 32°C group (44.4%) met the primary end point compared with 2 of 18 in the 34°C group (11.1%) (log-rank $P$=0.12). All patients whose initial rhythm was asystole died before 6 months in both groups. Eight of 13 patients with initial shockable rhythm assigned to 32°C (61.5%) were alive free from severe dependence at 6 months compared with 2 of 13 (15.4%) assigned to 34°C (log-rank $P$=0.029). The incidence of complications was similar in both groups except for the incidence of clinical seizures, which was lower (1 versus 11; $P$=0.0002) in patients assigned to 32°C compared with 34°C. On the contrary, there was a trend toward a higher incidence of bradycardia (7 versus 2; $P$=0.054) in patients assigned to 32°C. Although potassium levels decreased to a greater extent in patients assigned to 32°C, the incidence of hypokalemia was similar in both groups.

***Conclusions***—The findings of this pilot trial suggest that a lower cooling level may be associated with a better outcome in patients surviving out-of-hospital cardiac arrest secondary to a shockable rhythm. The benefits observed here merit further investigation in a larger trial in out-of-hospital cardiac arrest patients with different presenting rhythms.

***Clinical Trial Registration***—URL: http://www.clinicaltrials.gov. Unique identifier: NCT01155622.

(***Circulation***. **2012;126:2826-2833.**)

**Circulation. 2012;126:2826-2833**

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

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

Niklas Nielsen, M.D., Ph.D., Jørn Wetterslev, M.D., Ph.D., Tobias Cronberg, M.D., Ph.D., David Erlinge, M.D., Ph.D., Yvan Gasche, M.D., Christian Hassager, M.D., D.M.Sci., Janneke Horn, M.D., Ph.D., Jan Hovdenes, Jesper Kjaergaard, M.D., D.M.Sci., Michael Kuiper, M.D., Ph Pascal Stammet, M.D., Michael Wanscher, M.D., Ph.D., M Anders Åneman, M.D., Ph.D., Nawaf Al-S Søren Boesgaard, M.D., D.M.Sci., John Bro-Jeppesen, Jan Frederik Bugge, M.D., Ph.D., Christopher D. Nicole P. Juffermans, M.D., Ph.D., Matty Koopr Lars Køber, M.D., D.M.Sci., Jørund Langørgen, M. Jacob Eifer Møller, M.D., D.M.Sci., Malin Rund Christian Rylander, M.D., Ph.D., Ondrej Smid, M.D., Per Winkel, M.D., D.M.Sci., and Hans Friber for the TTM Trial Investigators

ABSTRACT

**BACKGROUND**

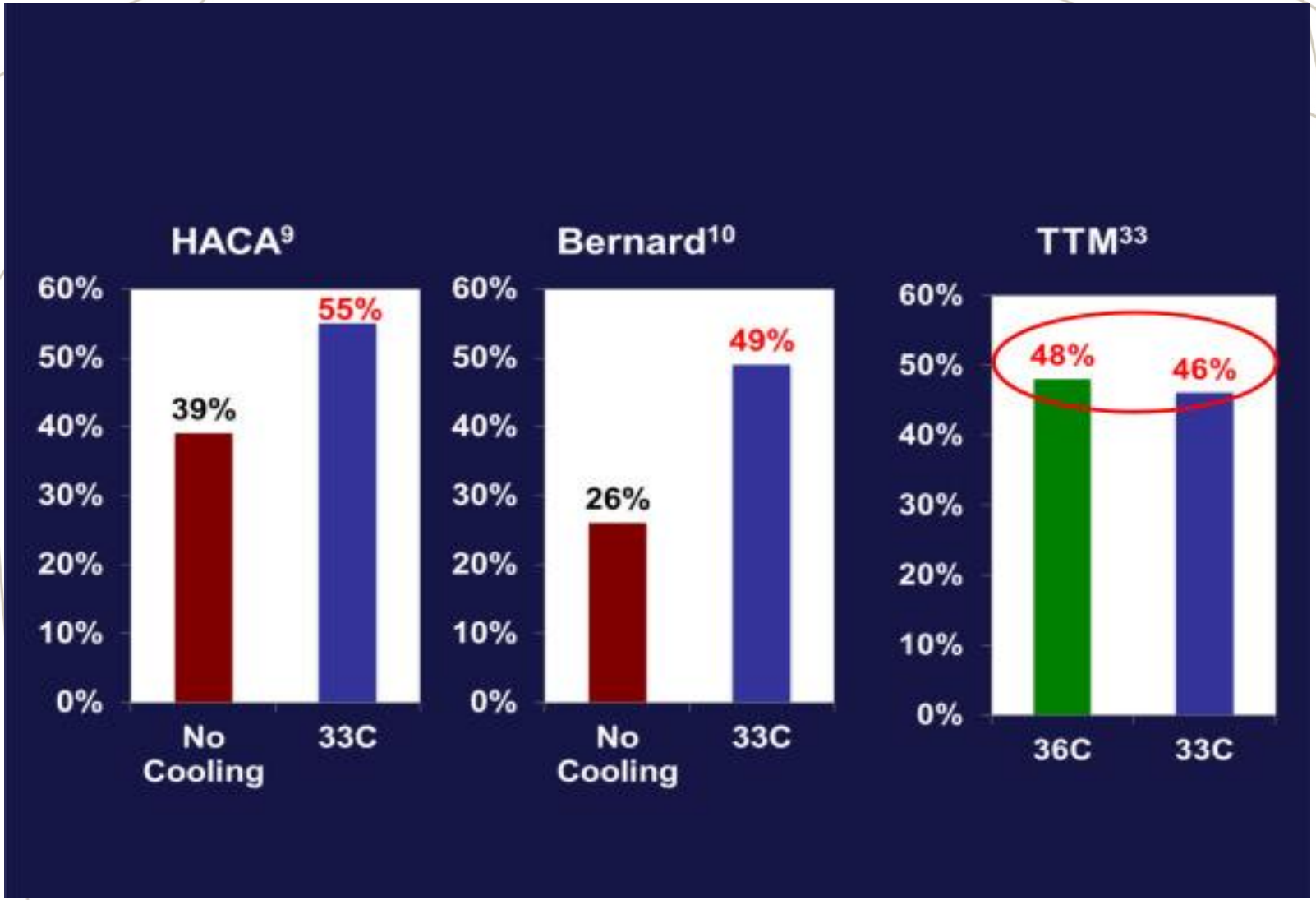
Unconscious survivors of out-of-hospital cardiac arrest have a high risk of death or poor neurologic function. Therapeutic hypothermia is recommended by international guidelines, but the supporting evidence is limited, and the target temperature associated with the best outcome is unknown. Our objective was to compare two target temperatures, both intended to prevent fever.

**METHODS**

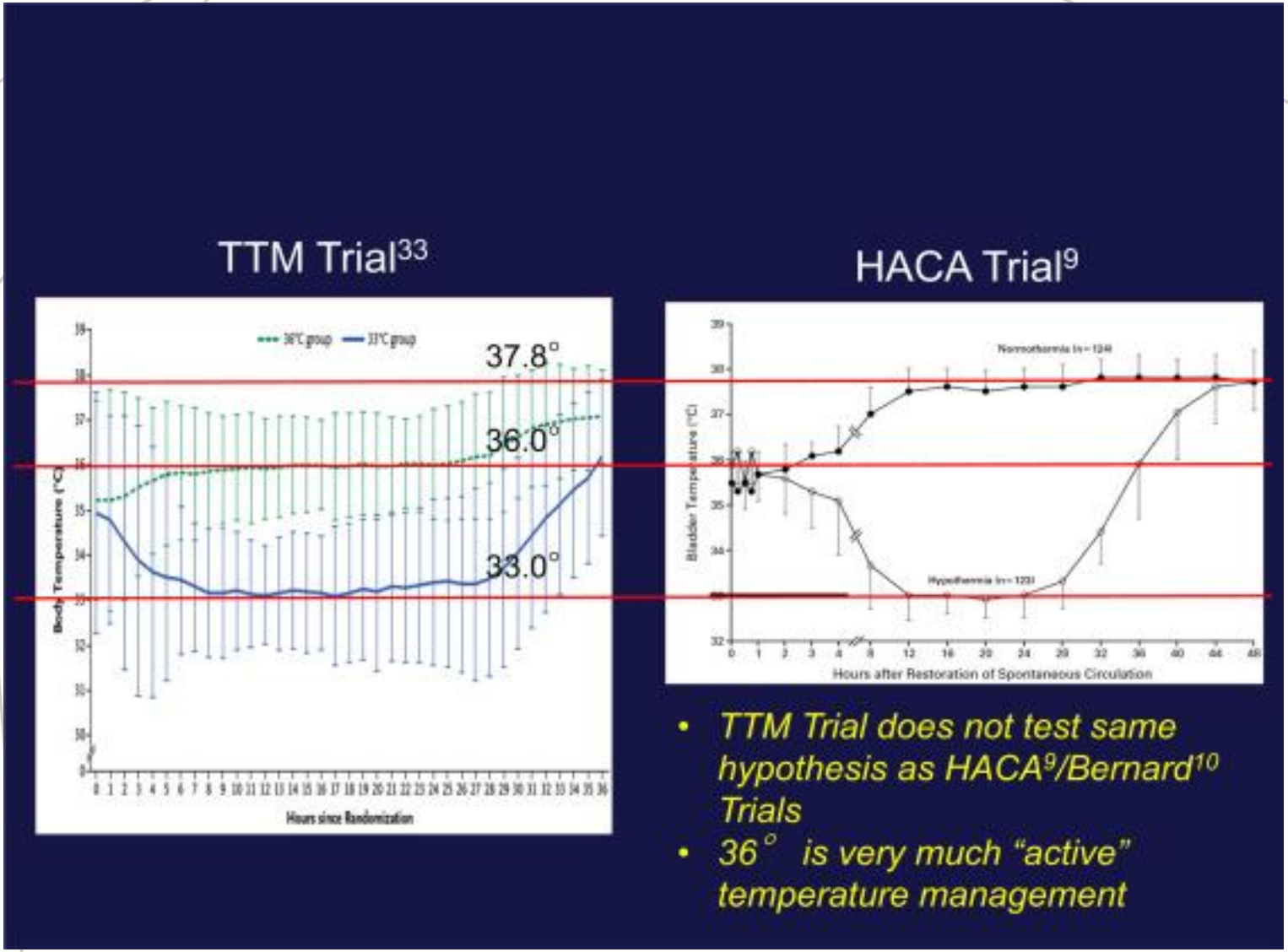
In an international trial, we randomly assigned 950 unconscious adults after out-of-hospital cardiac arrest of presumed cardiac cause to targeted temperature management at either 33°C or 36°C. The primary outcome was all-cause mortality through the end of the trial. Secondary outcomes included a composite of poor neurologic function or death at 180 days, as evaluated with the Cerebral Performance Category (CPC) scale and the modified Rankin scale.

**RESULTS**

In unconscious survivors of out-of-hospital cardiac arrest of presumed cardiac cause, hypothermia at a targeted temperature of 33°C did not confer a benefit as compared with a targeted temperature of 36°C.




Good Neurologic Outcomes in Major Temperature Management Trials. (Modified from Abella B. at https://www.med.upenn.edu/resuscitation/ttm-video.shtml).




TTM Trial in Context With Prior Studies. (Modified from Abella B. at https://www.med.upenn.edu/resuscitation/ttm-video.shtml).

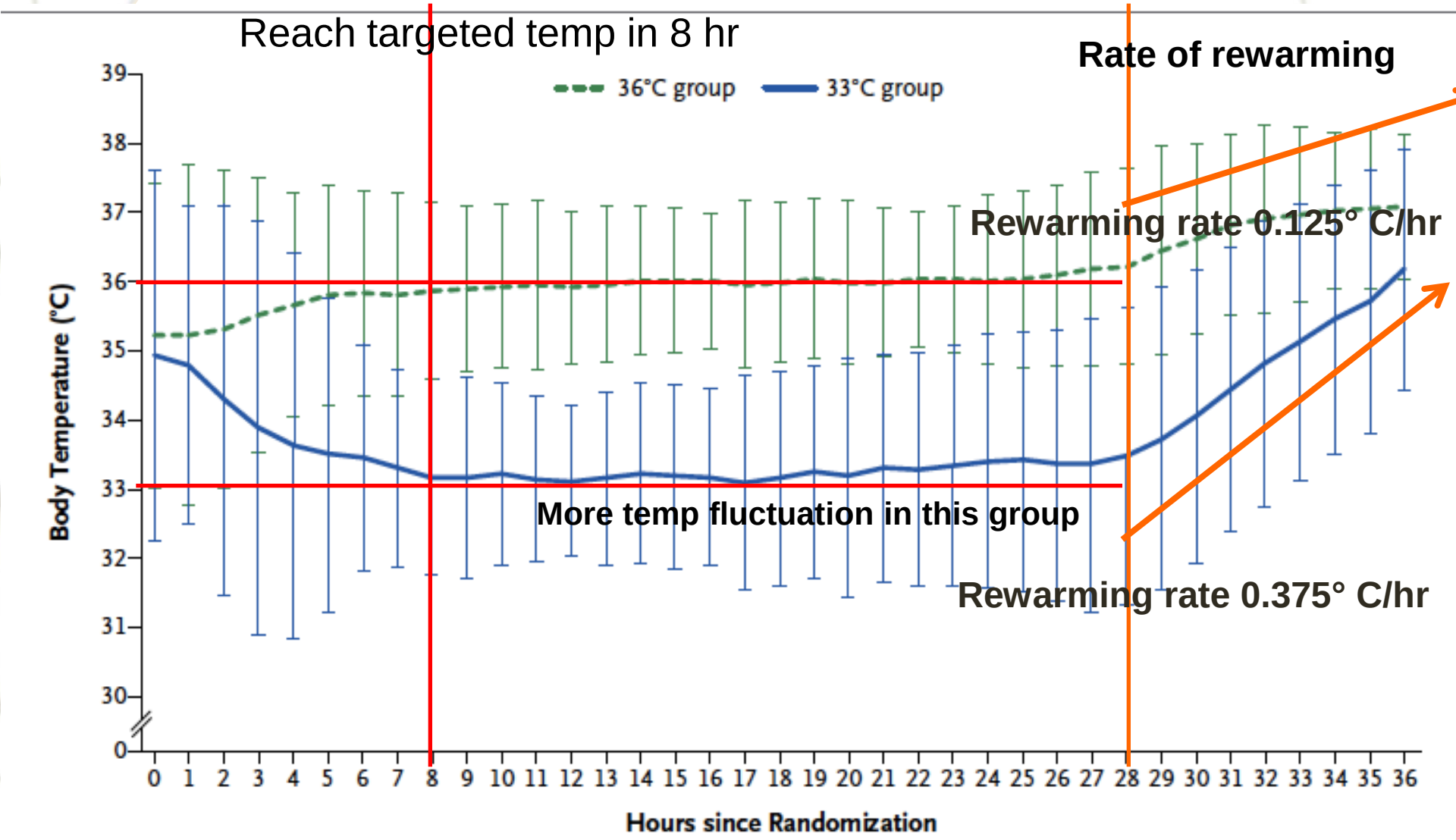
**Table 1. Characteristics of the Modified Intention-to-Treat Population before Randomization.***

| Characteristic | 33°C Group (N=473) | 36°C Group (N=466) |
|---|---|---|
| **Demographic characteristics** | | |
| Age — yr | 64±12 | 64±13 |
| Male sex — no. (%) | 393 (83) | 368 (79) |
| **Medical history — no. (%)** | | |
| Chronic heart failure | 32 (7) | 29 (6) |
| Previous AMI | 107 (23) | 86 (18) |
| Ischemic heart disease | 145 (31) | 115 (25) |
| Previous cardiac arrhythmia | 87 (18) | 79 (17) |
| Arterial hypertension | 193 (41) | 181 (39) |
| Previous TIA or stroke | 35 (7) | 38 (8) |
| Diabetes mellitus | 61 (13) | 80 (17) |
| Asthma or COPD | 48 (10) | 49 (11) |
| Previous percutaneous coronary intervention | 58 (12) | 50 (11) |
| Previous coronary-artery bypass grafting | 47 (10) | 42 (9) |

More comorbidity

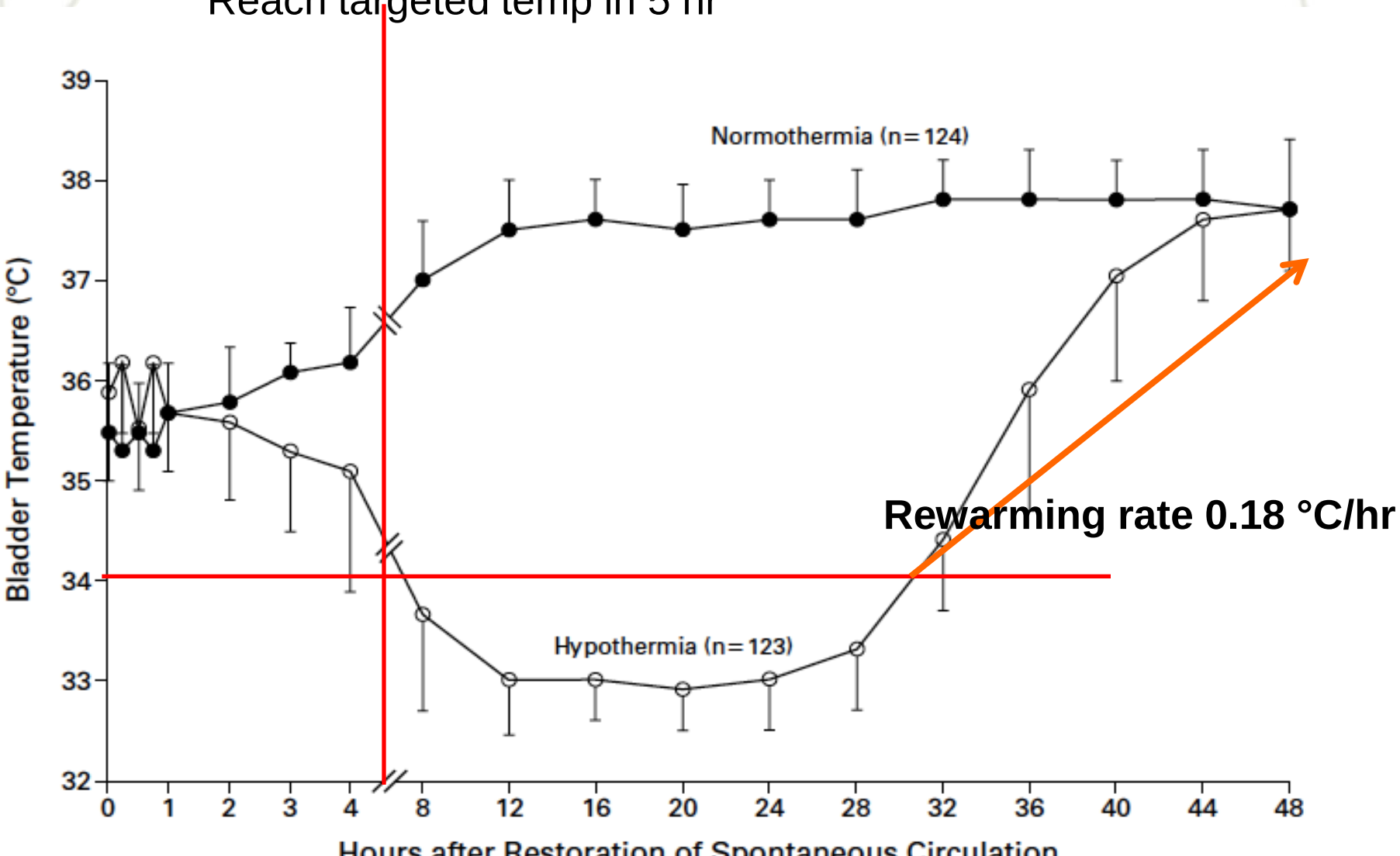
*n engl j med 369;23 nejm.org december 5, 2013*

# Temperature curve in TTM trial



# Temperature curve in HACA

Reach targeted temp in 5 hr

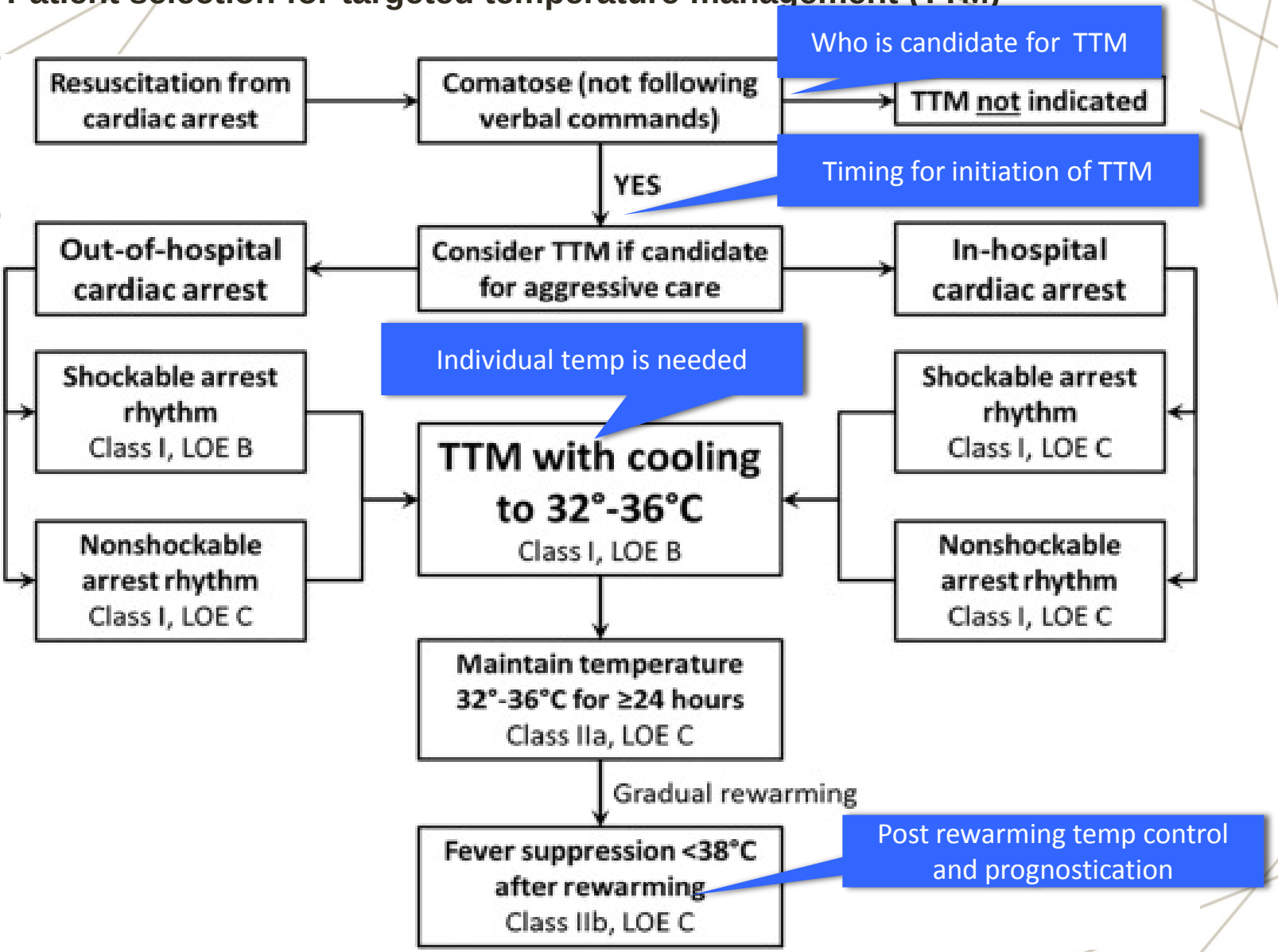



**Rewarming rate 0.18 °C/hr**

# Comment for TTM trial

- Patients requiring chest compressions for >20 minutes were excluded, select lessl ikely benefit from lower temp, and uncommon in the real world
- In TTM trial start cooling up to 4 hr time to targeted temp 8 hr ( total 12 hr, quite long) compare to HACA 105 min in average, slow cooling rate may affect some patient with severe brain injury
- TTM trail has rapid rewarm rate (6 hr) ?? Rebound hyperthermia in 33° C group
- **Pending the results of further studies which should compare different temperature levels (32° C, 34° C, and 36° C) and determine optimal duration (24, 48, or 72 hours) of TH**

# Patient selection for targeted temperature management (TTM)

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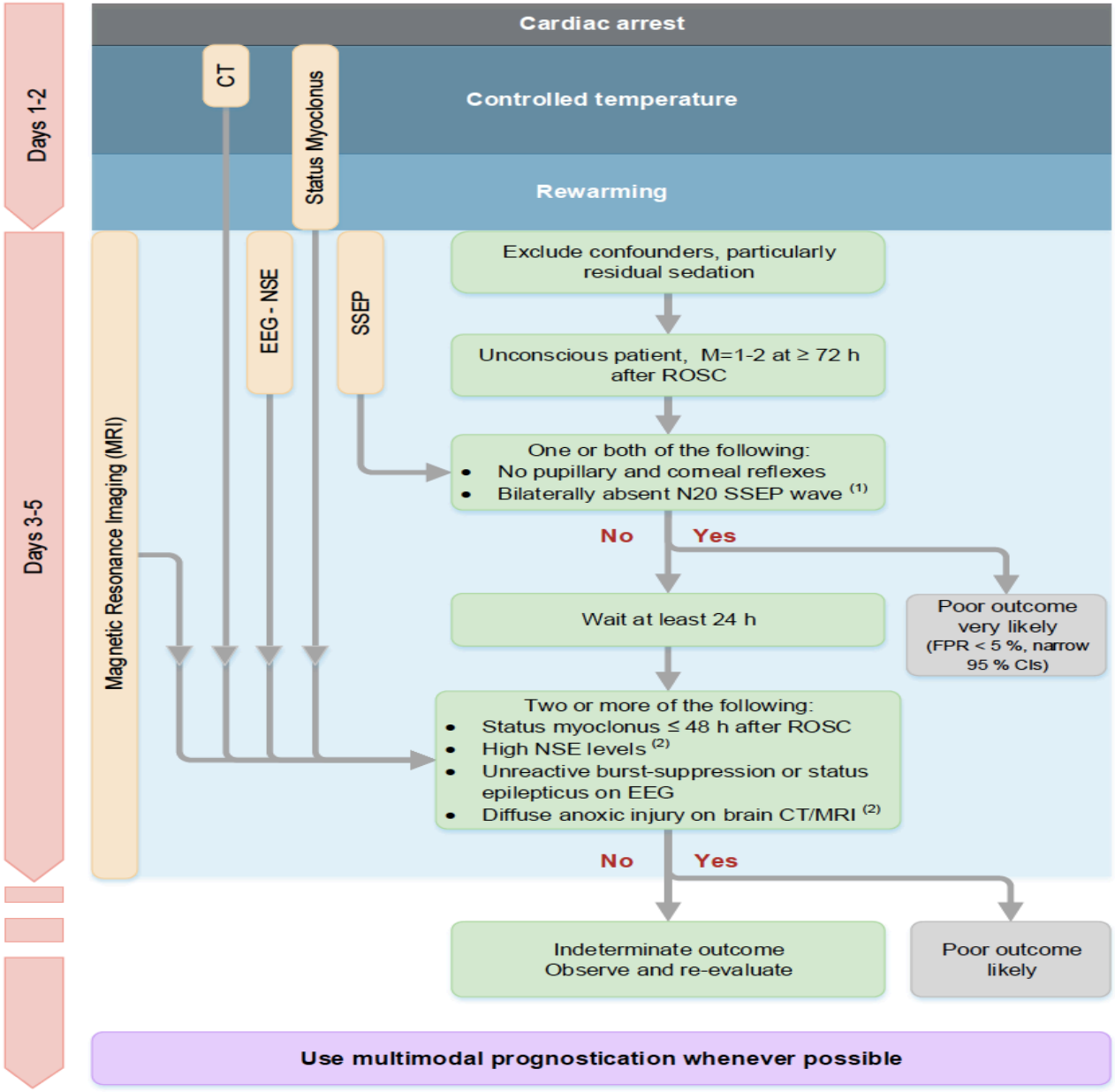
Resuscitation Council (UK) GUIDELINES 2015

# Prognostication for Comatose Survivors of Cardiac Arrest




(1) At ≥ 24 h after ROSC in patients not treated with targeted temperature
(2) See text for details.

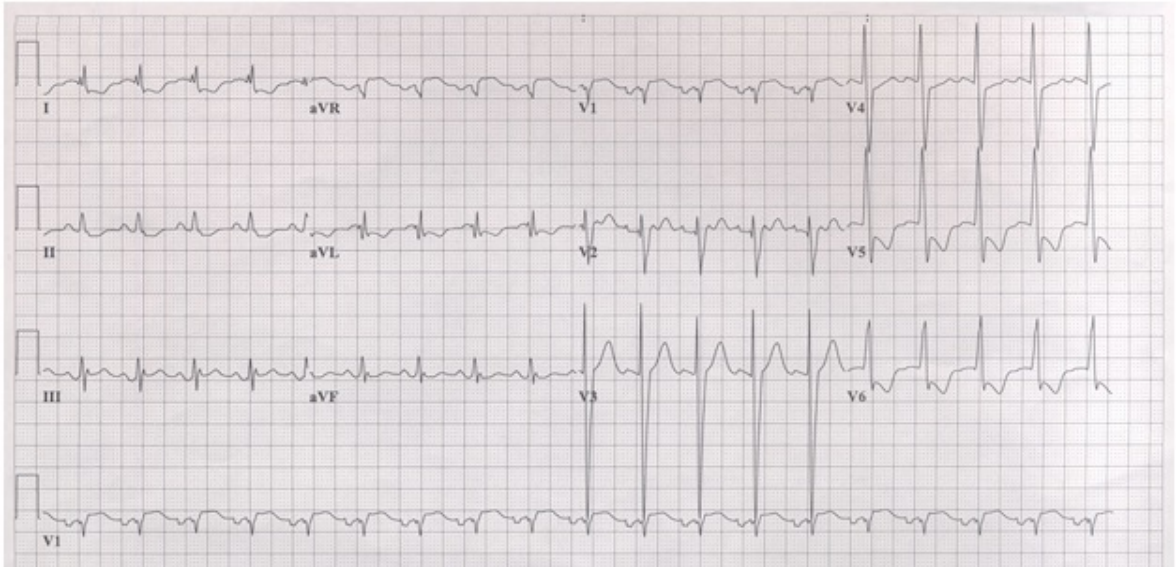
# TTM post cardiac arrest

- All comatose post cardiac arrest should be sent to TTM, choose the good candidate is challenging issue for cost effectiveness.
- Timing to initiate TTM is no data usually less than 12 hr
- TTM range is 32-36 ° C each patient required difference temp for brain recovery
- After rewarming should control temp at 37 at least 24-48 hr
- Prognostication should be done after 72 hr but MAKE SURE that no sedative effect.

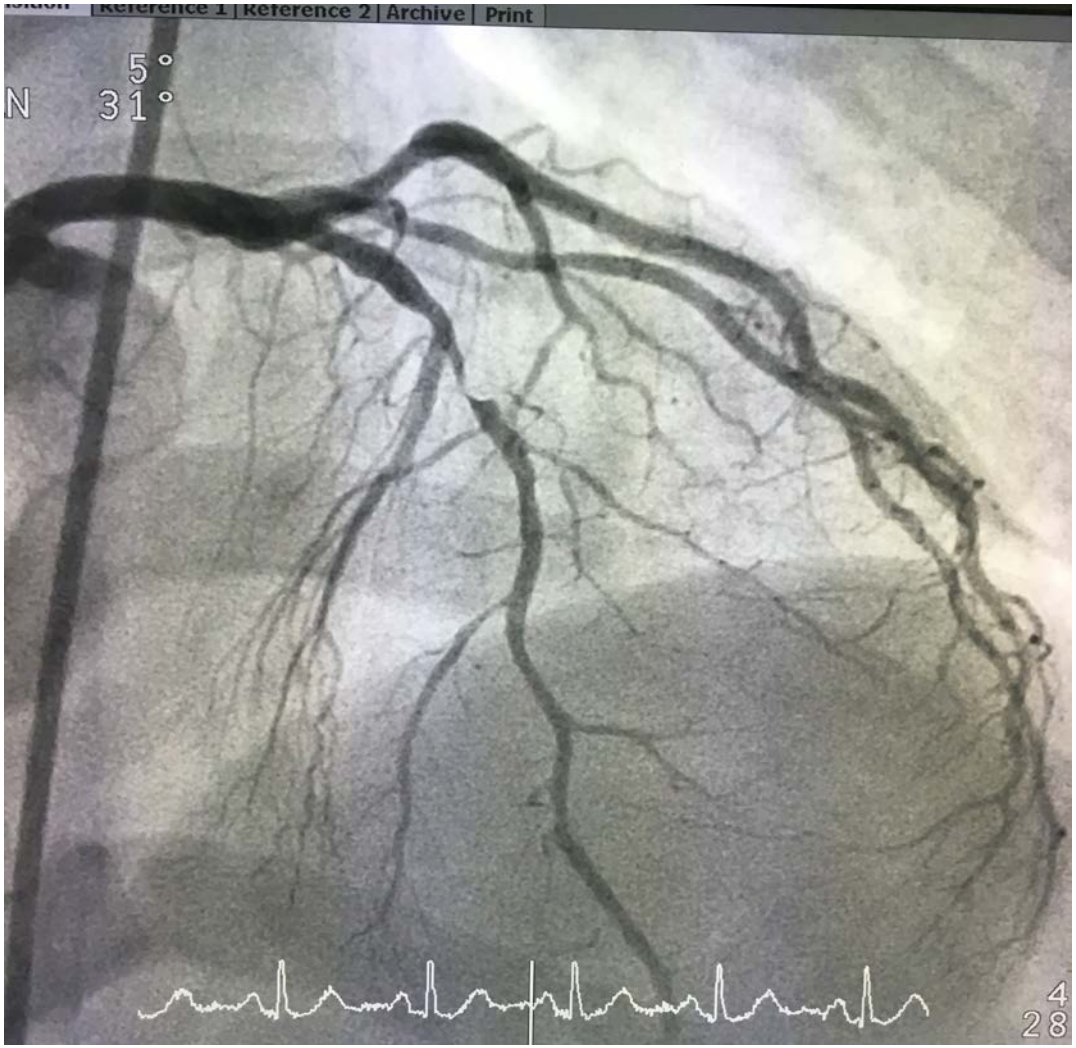
# Coronary revascularization in post cardiac arrest

- CAG emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).
- Emergency CAG is reasonable for select (eg, electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).
- CAG is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).

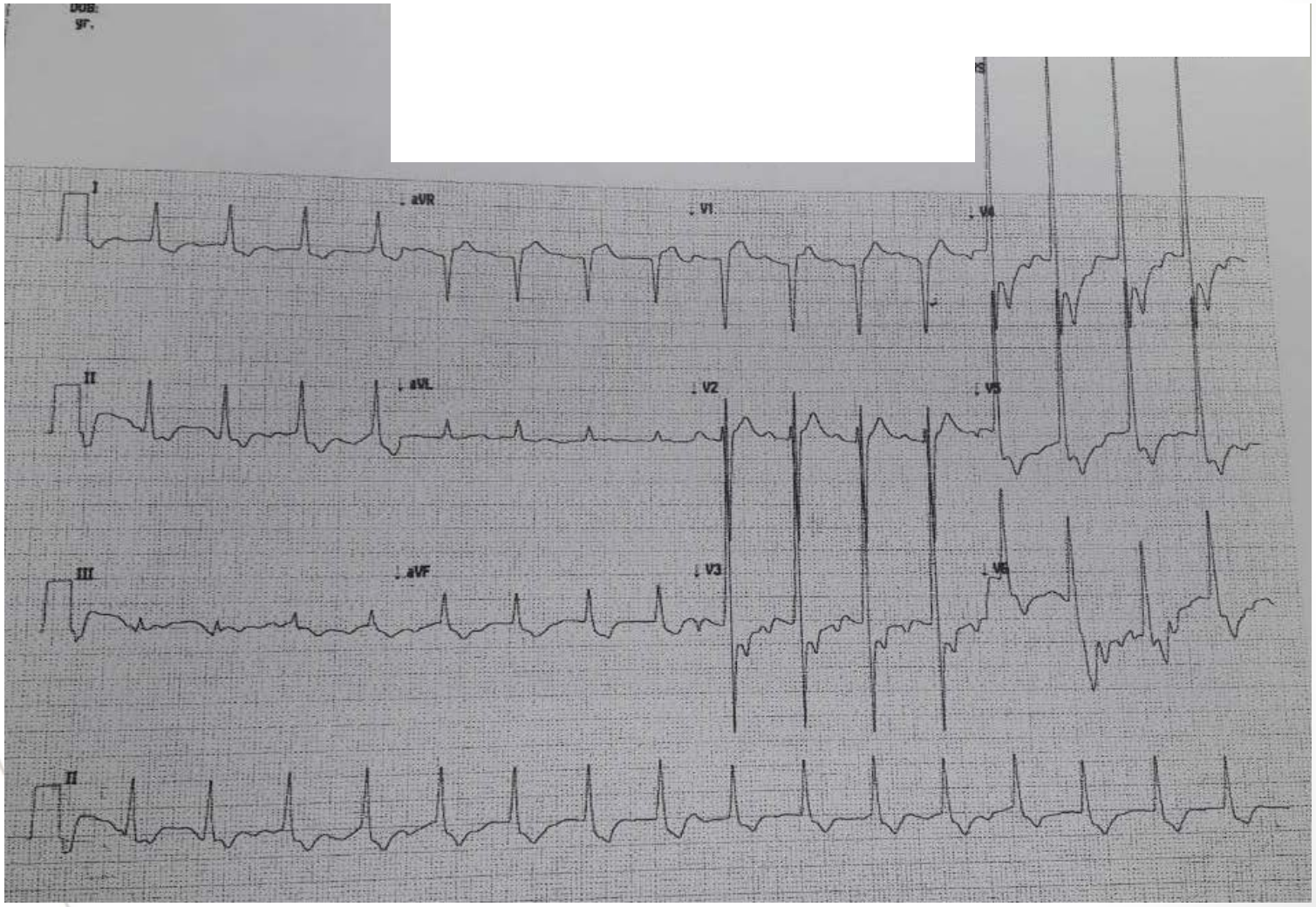
- 72 male unkonw underlying, present with acute pulmonary edema,cardiogenic shock and post cardiac arrest from PEA.



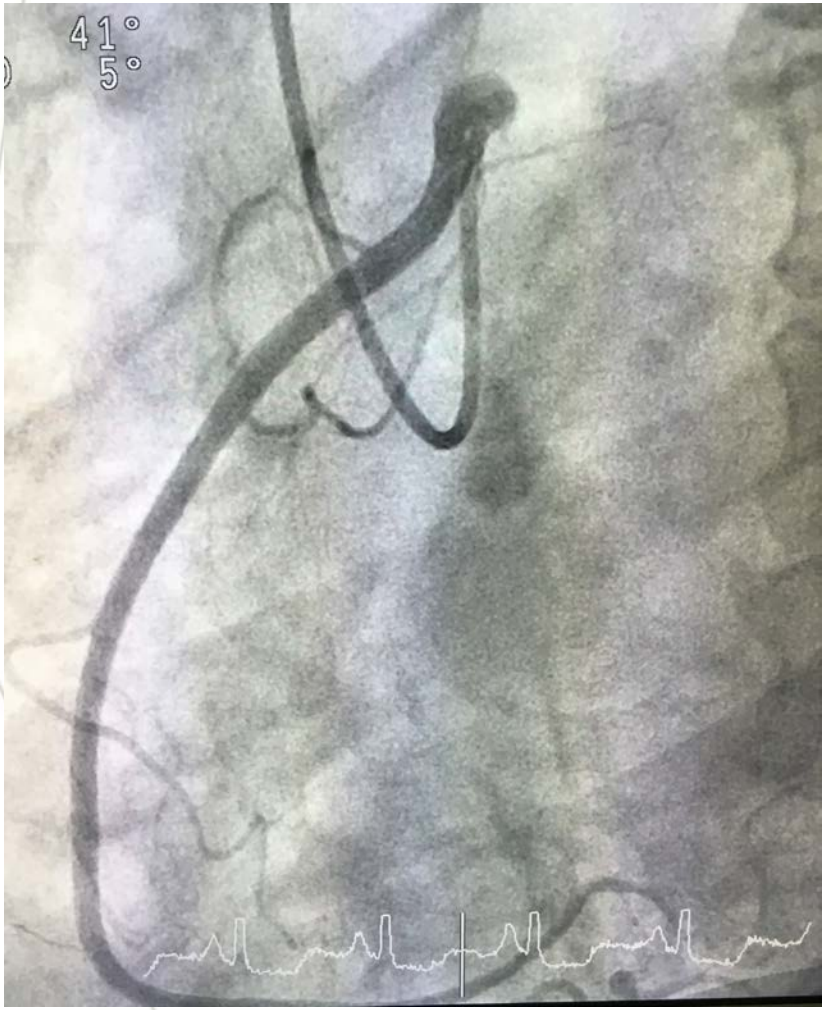
# CAG

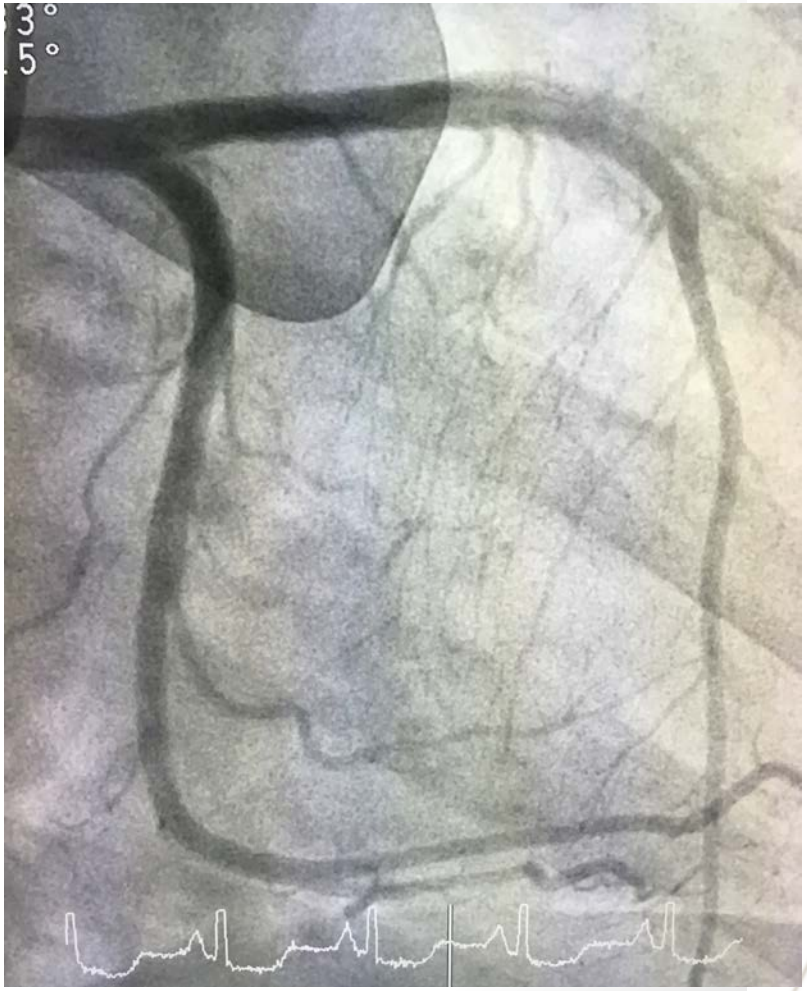


# 73 yr female with pVT arrest, CPR 10min x 2 episodes, troponin-T 2000+, ECG post arrest



# CAG result



# How can we identify the real ACS?

ECG matter??

**TABLE 2 Angiographic Findings in Patients With Cardiac Arrest and No ST-Segment Elevation on ECG**

| First Author, Year (Ref. #) | Acute Occlusion | Culprit Lesion* | Significant CAD† |
|---|---|---|---|
| Merchant et al., 2008 (55) | 6/17 (35) | – | 10/17 (55) |
| Reynolds et al., 2009 (14) | – | – | 31/54 (57) |
| Anyfantakis et al., 2009 (56) | – | – | 27/44 (61) |
| Radsel et al., 2011 (31) | 4/54 (7) | 13/54 (24) | 32/54 (59) |
| Bro-Jeppesen et al., 2012 (30) | – | – | 43/82 (52) |
| Dumas et al., 2010 (3) | – | – | 176/301 (58) |
| Hollenbeck et al., 2014 (25) | 44/163 (27) | – | – |
| Kern et al., 2015 (52) | 23 | 33 | – |
| Total (%) | 23 | 29 | 58 |

Values are n/N (%) or %. *Defined as acute occlusion or irregular plaque morphology with or without thrombus. †Defined according to the definition used in each study.

CAD = coronary artery disease; ECG = electrocardiogram.

**TABLE 3** Outcomes of Patients With Cardiac Arrest Referred for Coronary Angiography

| First Author, Year (Ref. #) | No STE | Early CAG Group (Includes Patients With and Without STE, Unless Otherwise Indicated) | | | No/Late CAG Group | | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Early CAG | PCI (% of CAG) | Survival/Good Outcome (% of CAG) | No/Late CAG | PCI | Survival/Good Outcome | |
| Dumas et al., 2010 (3) | 301 (69) | 435 (100) | 202 (46) | 171 (39) | – | – | – | All patients studied got CAG; successful PCI was an independent predictor of survival, adjusted OR: 2.06; 95% CI: 1.16–3.66; p = 0.013. |
| Nanjayya et al., 2011 (59) | NA | 35 (50) | 21 (60) | 18 (51) | 35 (50) | 1 (2) | 12 (34) | Adjusted odds for survival with good neurological outcome with CAG: 1.32; 95% CI: 0.26–7.37; p = 0.78. |
| Mooney et al., 2011 (12) | 72 (51) | 101 (72) | 56 (55) | 63 (62) | 39 (29) | – | 15 (38) | It is not indicated whether the use of CAG was included in the multivariate analysis of factors related to survival. |
| Aurore et al., 2011 (61) | 367 (82) | 133 (30) | 71 (53) | 30 (23) | 312 (70) | – | 30 (9.6) | p values for comparisons not provided. |
| Tømte et al., 2011 (37) | NA | 145 (83) | 80 (55) | 76 (52) | 29 (17) | – | 9 (31) | Adjusted odds for good outcome with emergency CAG: 11.21; 95% CI: 2.96–42.49; p < 0.001. |
| Stub et al., 2011 (28) | 46 (37) | 82 (66) | 41 (50) | – | 43 (34) | – | – | Also included conscious patients; unadjusted OR for survival with CAG: 7.6; 95% CI: 3.2–17.5; p = 0.01. Adjusted analysis not performed. |
| Strote et al., 2012 (58) | 158 (66) | 61 (25) | 38 (62) | 44 (72) | 179 (75) | 13 (30)† | 87 (49) | Assessed survival by terciles of likelihood of getting CAG. In highest tercile group, survival was higher with early CAG (73% vs. 33%; p = 0.001). |
| Zanuttini et al., 2012 (10) | 61 (66) | 48 (52) | 25 (52) | 29 (60) | 45 (48) | 6 (33)† | 21 (47) | Adjusted odds for survival overall with successful PCI: 2.32; 95% CI: 1.23–4.38; p = 0.009. |
| Cronier et al., 2011 (11) | 61 (55) | 91 (82) | 46 (51) | NA | – | – | – | Only patients without hemodynamic instability got CAG; adjusted OR for death with PCI: 0.30; 95% CI: 0.11–0.79; p = 0.01. |
| Bro-Jeppesen et al., 2012 (30) | 244 (68) | 82 (34)* | 24 (29)* | 54 (66)* | 162 (66)* | – | 83 (53)* | Adjusted HR for mortality in with emergency CAG in group without STE: 0.69; 95% CI: 0.4–1.2; p = 0.18. |
| Søholm et al., 2013 (60) | 1,020 (84) | 128 (13)* | NA | NA | 892 (87)* | NA | NA | Univariate OR for 30-day mortality with early CAG: 0.35; 95% CI: 0.18–0.70; p = 0.003; early CAG was not an independent predictor of mortality. |
| Hollenbeck et al., 2014 (25) | 269 (100) | 122 (45) | 40 (33) | 80 (66) | 147 (55) | 16 (11)† | 71 (49) | Adjusted OR for mortality with CAG: 0.35; 95% CI: 0.18–0.70; p = 0.003. |
| Callaway et al., 2014 (43) | 3,408 (86) | 765 (19) | 705 (92) | 495 (65) | 3,216 (81) | – | 871 (27) | Adjusted OR for survival with early CAG: 1.69; 95% CI: 1.06–2.70 |

Values are n (%). *Among those without STE. †Among those getting CAG.

CAG = coronary angiography; CI = confidence interval; HR = hazard ratio; NA = not available; OR = odds ratio; PCI = percutaneous coronary intervention; STE = ST-segment elevation; STEMI = ST-segment elevation myocardial infarction.

**TABLE 1** 28 Clinical Reports of Combining TTM and Early Coronary Angiography in Resuscitated, But Comatose Patients With STEMI on the ECG

| First Author, Date (Ref. #) | Survivors to DC (n = 2,687/4,510 [60%]) | Good Neuro Among Survivors (n = 2,090/2,426 [86%]) |
|---|---|---|
| Hovdenes et al., 2007 (17) | 41/50 | 34/41 |
| Richling et al., 2007 (33) | 24/46 | 22/24 |
| Knafelj et al., 2007 (18) | 30/40 | 22/30 |
| Wolfrum et al., 2008 (22) | 12/16 | 11/12 |
| Peels et al., 2008 (104) | 22/44 | NA |
| Schefold et al., 2009 (34) | NA | 19/31 |
| Reynolds et al., 2009 (14) | 52/96 | NA |
| Nielsen et al., 2009 (35) | 303/479 | 278/303 |
| Batista et al., 2010 (27) | 8/20 | 6/8 |
| Dumas et al., 2010 (3) | 171/435 | 160/171 |
| Koeth et al., 2010 (105) | 114/143 | NA |
| Stub et al., 2011 (28) | 52/81 | 46/52 |
| Laish-Farkash et al., 2011 (36) | 69/110 | 59/69 |
| Tømte et al., 2011 (37) | 140/252 | 132/140 |
| Radsel et al., 2011 (31) | 154/212 | 128/154 |
| Mooney et al., 2011 (12) | 78/140 | 72/78 |
| Cronier et al., 2011 (11) | 60/111 | 54/60 |
| Gräsner et al., 2011 (90) | 143/183 | 118/143 |
| Bro-Jeppesen et al., 2012 (30) | 211/360 | 207/219 |
| Zanuttini et al., 2012 (10) | 29/48 | NA |
| Liu et al., 2012 (106) | 36/81 | NA |
| Nanjayya et al., 2012 (59) | 18/35 | 14/18 |
| Strote et al., 2012 (58) | 44/61 | 34/44 |
| Waldo et al., 2013 (107) | 57/84 | NA |
| Velders et al., 2013 (32) | 187/222 | 168/183 |
| Callaway et al., 2014 (43) | 495/765 | 413/495 |
| Thomas et al., 2014 (108) | 168/348 | 115/168 |
| Sideris et al., 2014 (88) | 97/300 | 80/97 |

Values are n/N.

DC = discharge; ECG = electrocardiogram; neuro = neurological function; TTM = targeted temperature management.

# Outcomes of Comatose Cardiac Arrest Survivors With and Without ST-Segment Elevation Myocardial Infarction

## Importance of Coronary Angiography


**ABSTRACT**

**OBJECTIVES** The aim of this study was to compare outcomes and coronary angiographic findings in post-cardiac arrest patients with and without ST-segment elevation myocardial infarction (STEMI).

**BACKGROUND** The 2013 STEMI guidelines recommend performing immediate angiography in resuscitated patients whose initial electrocardiogram shows STEMI. The optimal approach for those without STEMI post-cardiac arrest is less clear.

**METHODS** A retrospective evaluation of a post-cardiac arrest registry was performed.

**RESULTS** The database consisted of 746 comatose post-cardiac arrest patients including 198 with STEMI (26.5%) and 548 without STEMI (73.5%). Overall survival was greater in those with STEMI compared with those without (55.1% vs. 41.3%; $p = 0.001$), whereas in all patients who underwent immediate coronary angiography, survival was similar between those with and without STEMI (54.7% vs. 57.9%; $p = 0.60$). A culprit vessel was more frequently identified in those with STEMI, but also in one-third of patients without STEMI (80.2% vs. 33.2%; $p = 0.001$). The majority of culprit vessels were occluded (STEMI, 92.7%; no STEMI, 69.2%; $p < 0.0001$). An occluded culprit vessel was found in 74.3% of STEMI patients and in 22.9% of no STEMI patients. Among cardiac arrest survivors discharged from the hospital who had presented without STEMI, coronary angiography was associated with better functional outcome (93.3% vs. 78.7%; $p < 0.003$).

**CONCLUSIONS** Early coronary angiography is associated with improved functional outcome among resuscitated patients with and without STEMI. Resuscitated patients with a presumed cardiac etiology appear to benefit from immediate coronary angiography. (J Am Coll Cardiol Intv 2015;8:1031–40) © 2015 by the American College of Cardiology Foundation.

Resuscitation 85 (2014) 1533–1540

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Resuscitation

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

Clinical paper

# Cardiac catheterization is associated with superior outcomes for survivors of out of hospital cardiac arrest: Review and meta-analysis☆

Anthony C. Camuglia[a,b,c,*], Varinder K. Randhawa[d], Shahar Lavi[d], Darren L. Walters[c,e]

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[e] The Prince Charles Hospital, Chermside, Brisbane, QLD, Australia

| Study or Subgroup | Acute angiography Events | Total | No acute Angiography Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Aurore 2011 | 31 | 133 | 30 | 312 | 8.2% | 2.86 [1.65, 4.96] |
| Bro-Jeppesen 2012 | 129 | 198 | 87 | 162 | 9.3% | 1.61 [1.05, 2.47] |
| Bulut 1999 | 4 | 10 | 10 | 27 | 2.9% | 1.13 [0.26, 5.01] |
| Cronier 2011 | 54 | 91 | 6 | 20 | 4.7% | 3.41 [1.20, 9.67] |
| Grasner 2011 | 80 | 154 | 57 | 430 | 9.3% | 7.07 [4.64, 10.78] |
| Hollenbeck 2013 | 80 | 122 | 71 | 147 | 8.7% | 2.04 [1.24, 3.34] |
| Mooney 2011 | 63 | 101 | 15 | 39 | 6.5% | 2.65 [1.24, 5.67] |
| Nanjayya 2012 | 18 | 35 | 12 | 35 | 5.2% | 2.03 [0.78, 5.31] |
| Nielsen 2009 | 303 | 479 | 187 | 507 | 10.6% | 2.95 [2.27, 3.82] |
| Reynolds 2009 | 40 | 63 | 22 | 33 | 5.6% | 0.87 [0.36, 2.11] |
| Strote 2012 | 44 | 61 | 88 | 179 | 7.5% | 2.68 [1.42, 5.03] |
| Tomte 2011 | 76 | 145 | 9 | 29 | 5.9% | 2.45 [1.04, 5.74] |
| Waldo 2013 | 57 | 84 | 7 | 26 | 5.1% | 5.73 [2.15, 15.27] |
| Werling 2007 | 19 | 28 | 10 | 57 | 4.7% | 9.92 [3.48, 28.25] |
| Zanuttini 2012 | 33 | 48 | 21 | 45 | 5.9% | 2.51 [1.08, 5.86] |
| **Total (95% CI)** | | **1752** | | **2048** | **100.0%** | **2.77 [2.06, 3.72]** |
| Total events | 1031 | | 632 | | | |

Heterogeneity: $Tau^2 = 0.20$; $Chi^2 = 43.27$, df = 14 ($P < 0.0001$); $I^2 = 68\%$
Test for overall effect: $Z = 6.79$ ($P < 0.00001$)

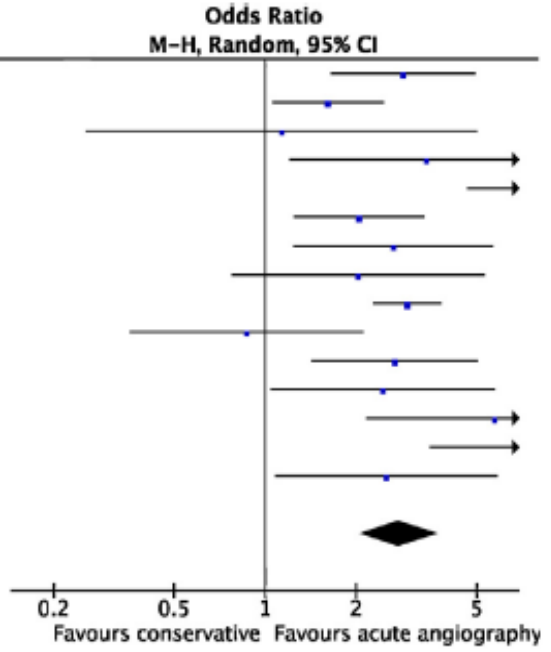



Fig. 2. Weighted hazard effects model of the relationship between acute coronary angiography and survival after OHCA.

| Study or Subgroup | Acute angiography Events | Total | No acute Angiography Events | Total | Weight | Odds Ratio M-H, Random, 95% CI |
|---|---|---|---|---|---|---|
| Bro-Jeppesen 2012 | 126 | 198 | 79 | 162 | 13.1% | 1.84 [1.20, 2.81] |
| Grasner 2011 | 80 | 154 | 57 | 430 | 13.1% | 7.07 [4.64, 10.78] |
| Hollenbeck 2013 | 74 | 122 | 65 | 147 | 12.5% | 1.94 [1.19, 3.17] |
| Mooney 2011 | 61 | 101 | 12 | 39 | 9.8% | 3.43 [1.56, 7.55] |
| Nanjayya 2012 | 14 | 35 | 11 | 35 | 8.1% | 1.45 [0.54, 3.89] |
| Nielsen 2009 | 278 | 479 | 169 | 507 | 14.4% | 2.77 [2.14, 3.58] |
| Reynolds 2009 | 33 | 63 | 19 | 33 | 9.2% | 0.81 [0.35, 1.89] |
| Strote 2012 | 48 | 61 | 138 | 179 | 10.5% | 1.10 [0.54, 2.22] |
| Tomte 2011 | 75 | 145 | 9 | 29 | 9.2% | 2.38 [1.02, 5.58] |
| **Total (95% CI)** | | **1358** | | **1561** | **100.0%** | **2.20 [1.46, 3.32]** |
| Total events | 789 | | 559 | | | |

Heterogeneity: $Tau^2 = 0.29$; $Chi^2 = 40.71$, df = 8 ($P < 0.00001$); $I^2 = 80\%$
Test for overall effect: $Z = 3.75$ ($P = 0.0002$)

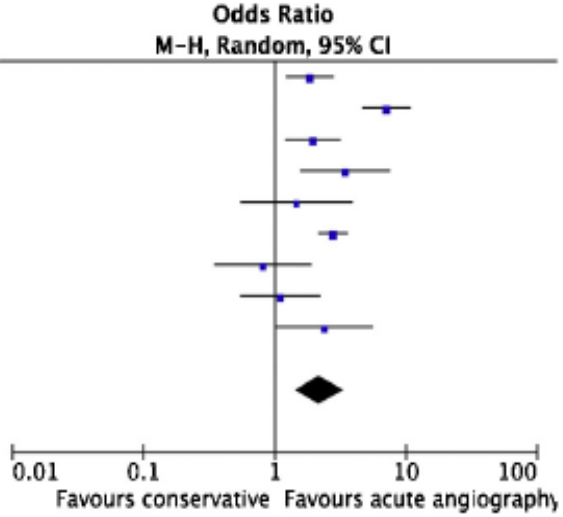
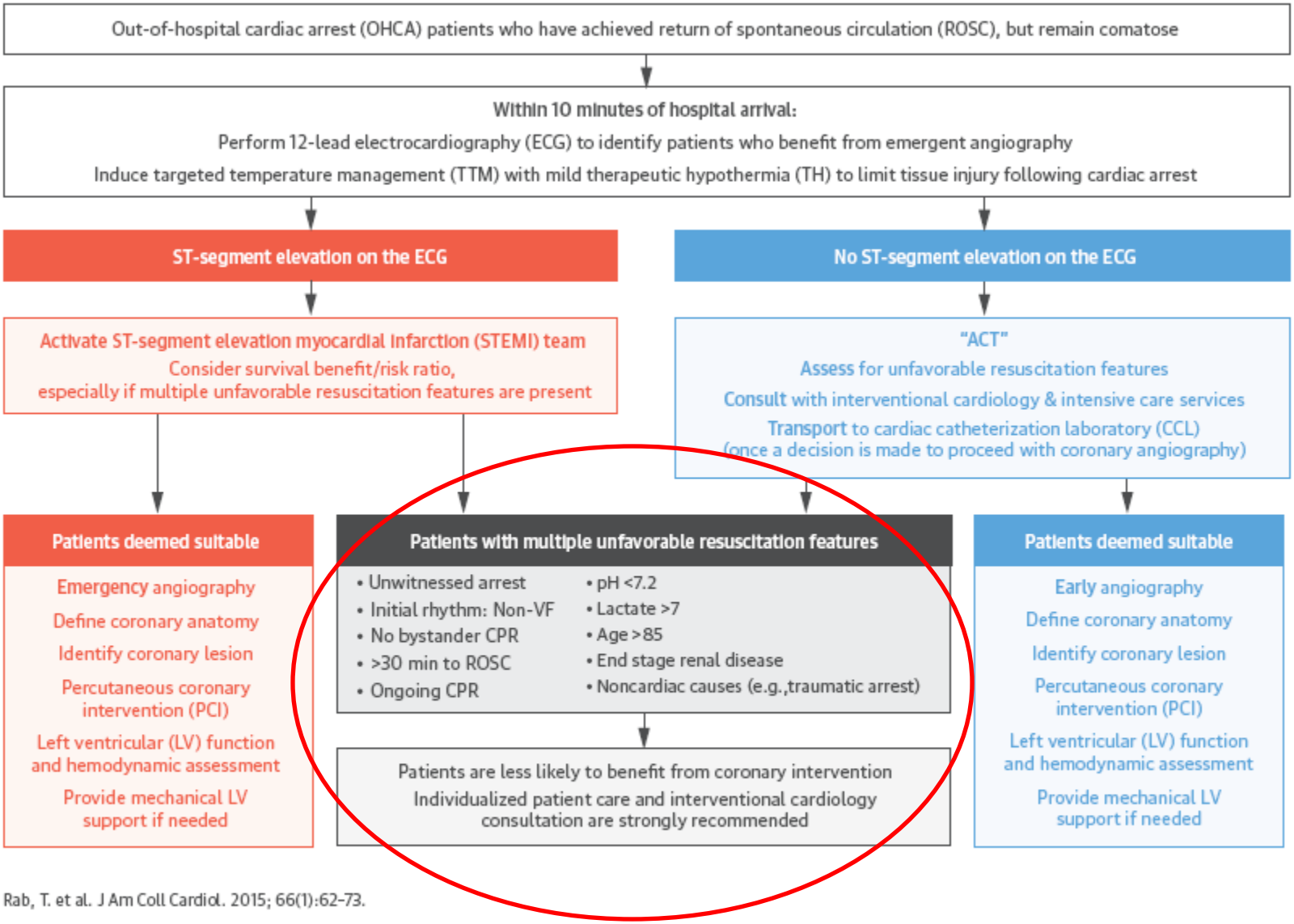



Fig. 3. Weighted hazard effects model of the relationship between acute coronary angiography and good neurological outcome after OHCA.

# Which patient worth for revascularization?

**CENTRAL ILLUSTRATION** **Algorithm for Risk Stratification of Comatose Cardiac Arrest Patients**




Rab, T. et al. J Am Coll Cardiol. 2015; 66(1):62–73.

ACT = assessment, consultation, transport; CCL = cardiac catheterization laboratory; CPR = cardiopulmonary resuscitation; ECG = electrocardiography; LV = left ventricular; OHCA = out-of-hospital cardiac arrest; PCI = percutaneous coronary intervention; ROSC = return of spontaneous circulation; STEMI = ST-segment elevation myocardial infarction; TH = therapeutic hypothermia; TTM = targeted temperature management; VF = ventricular fibrillation.

**Table 3 Factors predictive of a positive coronary angiography in univariate analysis**

| | Patients, *n* (%) | | | |
|---|---|---|---|---|
| | Positive[a] (*n* = 98) | Negative (*n* = 35) | OR (95% CI) | *P* value |
| Initial rhythm VF or VT | 73 (74) | 17 (49) | 2.9 (1.3–6.6) | 0.008 |
| Semiautomatic defibrillator on | 61 (62) | 13 (37) | 2.7 (1.2–5.9) | 0.02 |
| Public place | 48 (49) | 6 (17) | 4.6 (1.7–12.0) | 0.001 |
| History of coronary disease | 34 (35) | 3 (9) | 5.5 (1.6–19.3) | 0.004 |
| History of diabetes | 22 (22) | 2 (6) | 4.6 (1.0–20.9) | 0.03 |
| ST segment depression (ECG) | 40 (41) | 8 (23) | 2.2 (0.9–5.5) | 0.07 |
| Male | 86 (88) | 23 (66) | 3.7 (1.4–9.7) | 0.005 |
| ST segment elevation (ECG) | 51 (52) | 14 (40) | 1.6 (0.7–3.6) | 0.3 |

CI, confidence interval; ECG, electrocardiography; OR, odds ratio; VF, ventricular fibrillation; VT, ventricular tachycardia.
[a]Coronary angiography revealing at least one significant coronary lesion or percutaneous coronary intervention.

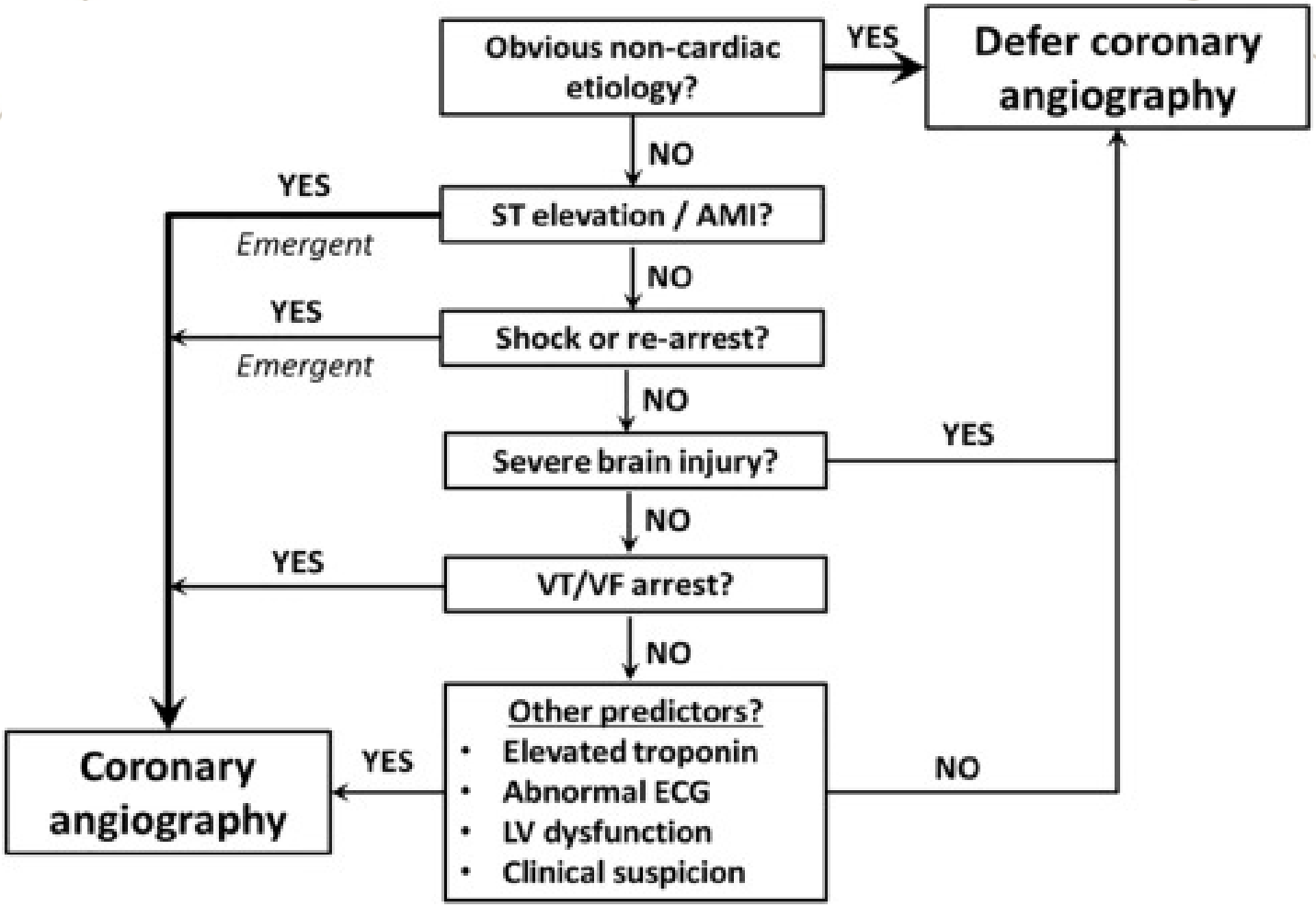
**Table 4 Independent factors predictive of a positive coronary angiography in multivariate analysis**

| | Odds ratio (95% CI) |
|---|---|
| Positive coronary angiography[a] | |
| History of diabetes | 7.1 (1.4–36.6) |
| ST segment depression (out-of-hospital ECG) | 5.4 (1.1–27.8) |
| History of coronary disease | 5.3 (1.4–20.1) |
| Cardiac arrest in a public place | 3.7 (1.3–10.7) |
| Initial rhythm VF or VT | 3.1 (1.1–8.6) |

CI, confidence interval; ECG, electrocardiography; VF, ventricular fibrillation; VT, ventricular tachycardia.
[a]Coronary angiography revealing at least one significant coronary lesion. The independent variables of the multiple logistic regression were factors with $P < 0.10$ in the univariate analysis. The *P* value in the Hosmer–Lemeshow goodness-of-fit test was 0.83, indicating good model fit.

| Guideline-Recommended Indications for Emergent Coronary Angiography After OHCA | Additional Suggested Indications for Coronary Angiography After OHCA |
| --- | --- |
| STE on ECG (class I) | Shockable arrest rhythm (ie, VF) |
| Hemodynamic instability or shock (class IIa) | Markedly elevated cardiac troponin levels |
| Recurrent VF (class IIa) | Ischemic ECG changes (other than STE) |
| Suspected acute MI (class IIa) | Left ventricular systolic dysfunction |
| | High pretest probability of CAD |

**Patient selection for coronary angiography after out-of-hospital cardiac arrest. Emergent coronary angiography is defined as within 2 hours, and routine coronary angiography is defined as within 24 hours. AMI indicates acute myocardial infarction; ECG,...**




Jacob C. Jentzer, Casey M. Clements, Joseph G. Murphy, R. Scott Wright

**Recent Developments in the Management of Patients Resuscitated From Cardiac Arrest ☆ ☆☆**

Journal of Critical Care, 2017, Available online 16 February 2017 http://dx.doi.org/10.1016/j.jcrc.2017.02.011

# Pitfalls in post cardiac arrest CAG

- Don’t rely on ECG post cardiac arrest or cardiac troponin.
- Always looking for other cause of CA  presenting with similar picture of ACS esp PE, Aortic dissection.
- Common misunderstand is CAG improve survival of post cardiac arrest, must be PCI successful case!!
- Challenging is to select the pt who worth for revascularization.

# Points of concern

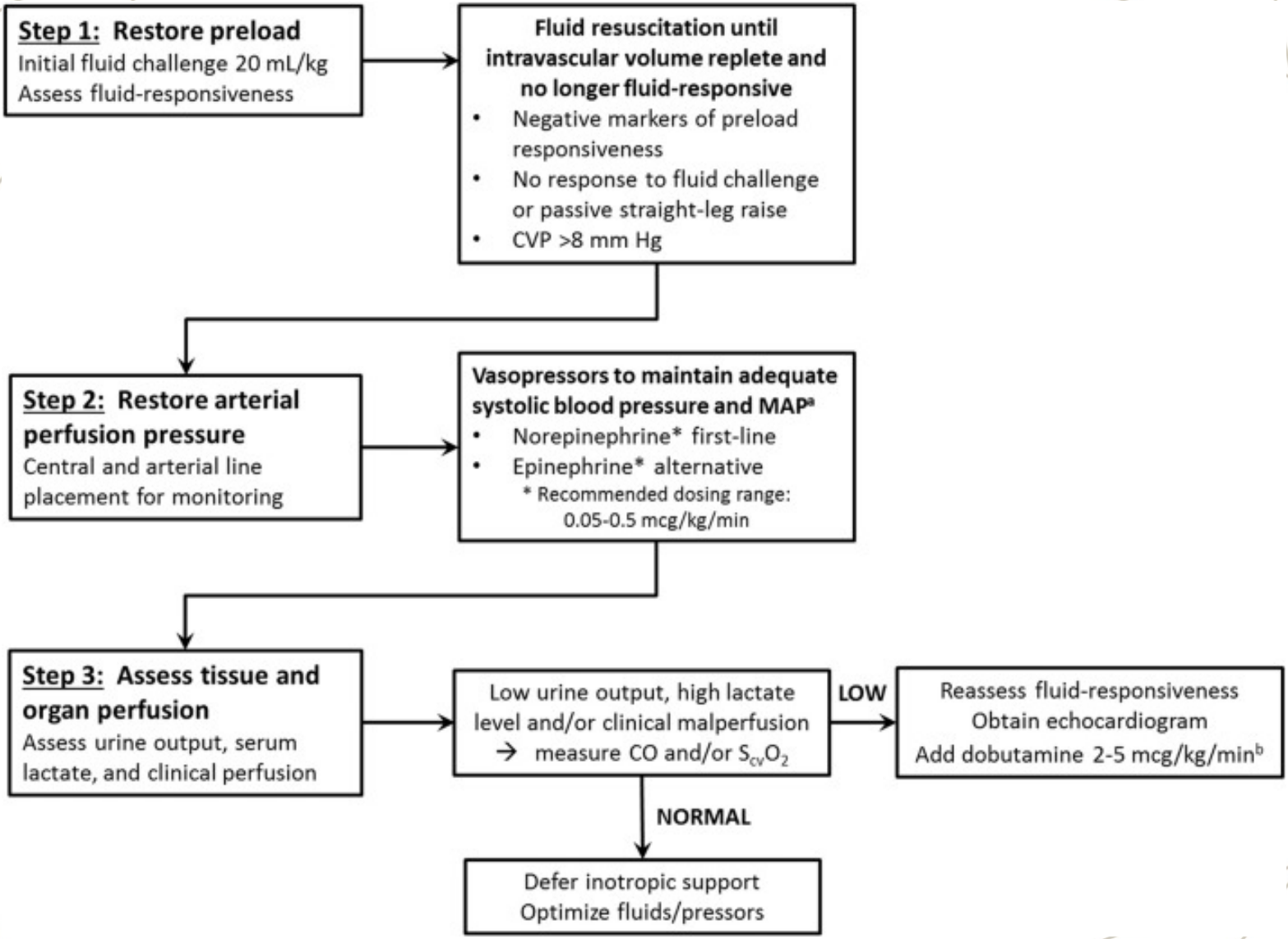
- Cost VS expected result/ overall prognosis!!

(Regardless of consciousness but if poor overall prognosis CAG should be delayed)

- Cath lab facilities, transferred time and interventionist skill.
- Other non cardiac cause of cardiac arrest and delayed management due to aggressive D2B time.
- ECPR may play role in the future to improve outcome

# Hemodynamic in post cardiac arrest

# Suggested early hemodynamic optimization strategy.




Jacob C. Jentzer, Casey M. Clements, Joseph G. Murphy, R. Scott Wright **Recent Developments in the Management of Patients Resuscitated From Cardiac Arrest ☆ ☆☆**
Journal of Critical Care, 2017, Available online 16 February 2017 http://dx.doi.org/10.1016/j.jcrc.2017.02.011

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Clinical paper

# Impact of mean arterial pressure on clinical outcomes in comatose survivors of out-of-hospital cardiac arrest: Insights from the University of Ottawa Heart Institute Regional Cardiac Arrest Registry (CAPITAL-CARe)☆

Juan J. Russo, Tyler E. James, Benjamin Hibbert, Altayyeb Yousef, Christina Osborne, George A. Wells, Michael P.V. Froeschl, Derek Y. So, Aun Yeong Chong, Marino Labinaz, Chris A. Glover, Jean-François Marquis, Alexander Dick, Jordan Bernick, Miche

*Departm*

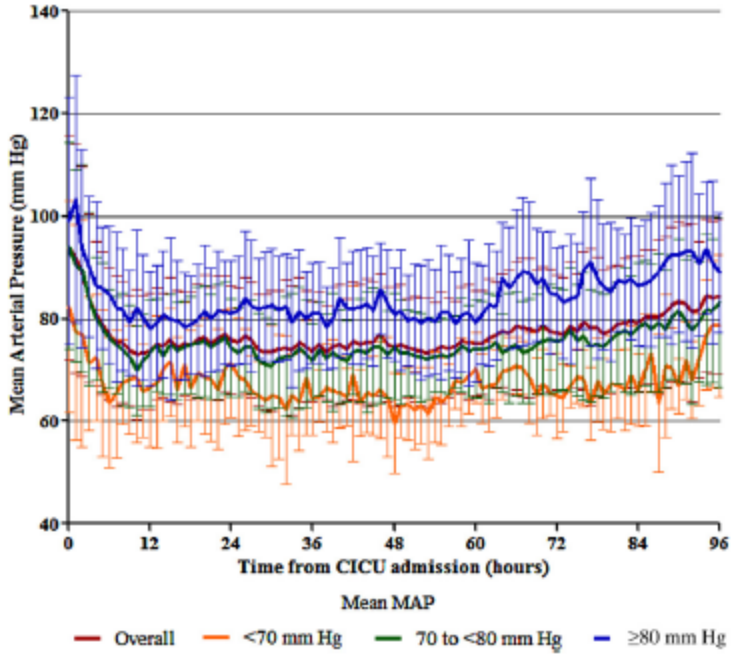


**Fig. 1.** Hourly mean MAP during first 96 h of CICU admission. MAP = mean arterial pressure; CICU = cardiac intensive care unit.

A B S T R A C T

*Aim of the study:* We sought to assess the relationship between mean arterial pressure (MAP) and clinical outcomes in comatose survivors of out-of-hospital cardiac arrest (OHCA).

*Methods:* We identified consecutive comatose survivors of OHCA with an initial shockable rhythm treated with targeted temperature management. We examined clinical outcomes in relation to mean MAP (measured hourly) during the first 96 h of hospitalization. Co-primary outcomes were the rates of death and severe neurological dysfunction at discharge.

*Results:* In 122 patients meeting inclusion criteria, death occurred in 29 (24%) and severe neurological dysfunction in 39 (32%). Higher mean MAPs were associated with lower odds of death (OR 0.55 per 5 mmHg increase; 95%CI 0.38–0.79; p = 0.002) and severe neurological dysfunction (OR 0.66 per 5 mmHg increase; 95%CI 0.48–0.90; p = 0.01). After adjustment for differences in patient, index event, and treatment characteristics, higher mean MAPs remained associated with lower odds of death (OR 0.60 per 5 mmHg increase; 95%CI 0.40–0.89; p = 0.01) but not severe neurological dysfunction (OR 0.73 per 5 mmHg increase; 95%CI 0.51–1.03; p = 0.07). The relationship between mean MAP and the odds of death (p-interaction = 0.03) and severe neurological dysfunction (p-interaction = 0.03) was attenuated by increased patient age.

*Conclusion:* In comatose survivors of OHCA treated with target temperature management, a higher mean MAP during the first 96 h of admission is associated with increased survival. The association between mean MAP and clinical outcomes appears to be attenuated by increased age.

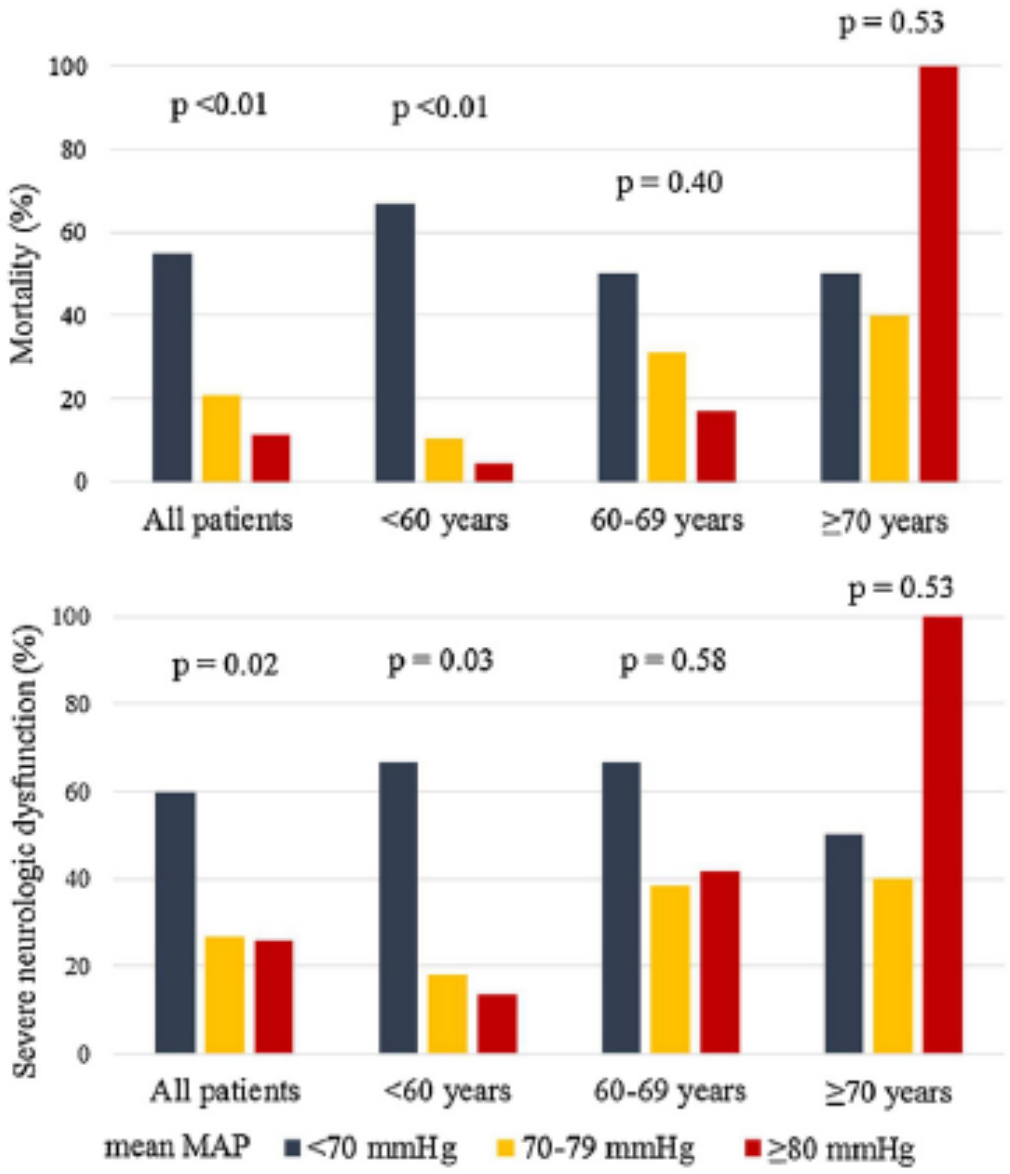


**Fig. 2.** Clinical outcomes stratified by mean MAP and age.
MAP = mean arterial pressure.

Resuscitation 85 (2014) 1142–1148

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Review

# The effect of hyperoxia on survival following adult cardiac arrest: A systematic review and meta-analysis of observational studies☆

Chih-Hung Wang[a,b], Wei-Tien Chang[a], Chien-Hua Huang[a], Min-Shan Tsai[a], Ping-Hsun Yu[c], An-Yi Wang[a], Nai-Chuan Chen[d], Wen-Jone Chen[a,e,*]

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ABSTRACT

*Objective:* Studies have shown the detrimental effect of hyperoxia in animals with return of spontaneous circulation (ROSC) after cardiac arrest. To maximize the value of existing clinical studies, we performed the systemic review and meta-analysis of human observational studies to examine the effect of hyperoxia on outcomes of post-ROSC patients.

*Methods:* We searched PubMed and Embase from the inception to October 2013. We selected adult observational studies that compared different levels of partial pressure of arterial oxygen ($PaO_2$) in post-ROSC patients with mortality or neurological status at hospital discharge as outcome. Studies comparing hypoxia with normoxia only were excluded.

*Results:* Fourteen studies were identified from 2982 references. Odds ratio (OR) was used as effect estimate. OR was reconstructed if not provided in original articles. Hyperoxia was defined as a $PaO_2$ >300 mmHg. Meta-analysis indicated that hyperoxia appeared to be correlated with increased in-hospital mortality (OR, 1.40; 95% CI, 1.02–1.93; $I^2$, 69.27%; 8 studies) but not worsened neurological outcome (OR, 1.62; 95% CI, 0.87–3.02; $I^2$, 55.61%; 2 studies). However, the results were inconsistent in subgroup and sensitivity analyses.

*Conclusions:* Hyperoxia appears to be correlated with increased in-hospital mortality of post-ROSC patients. This result should be interpreted cautiously because of the significant heterogeneity and limited number of studies analyzed. However, because exposure to hyperoxia had no obvious benefits, clinicians should monitor $PaO_2$ closely and titrate oxygen administration cautiously.

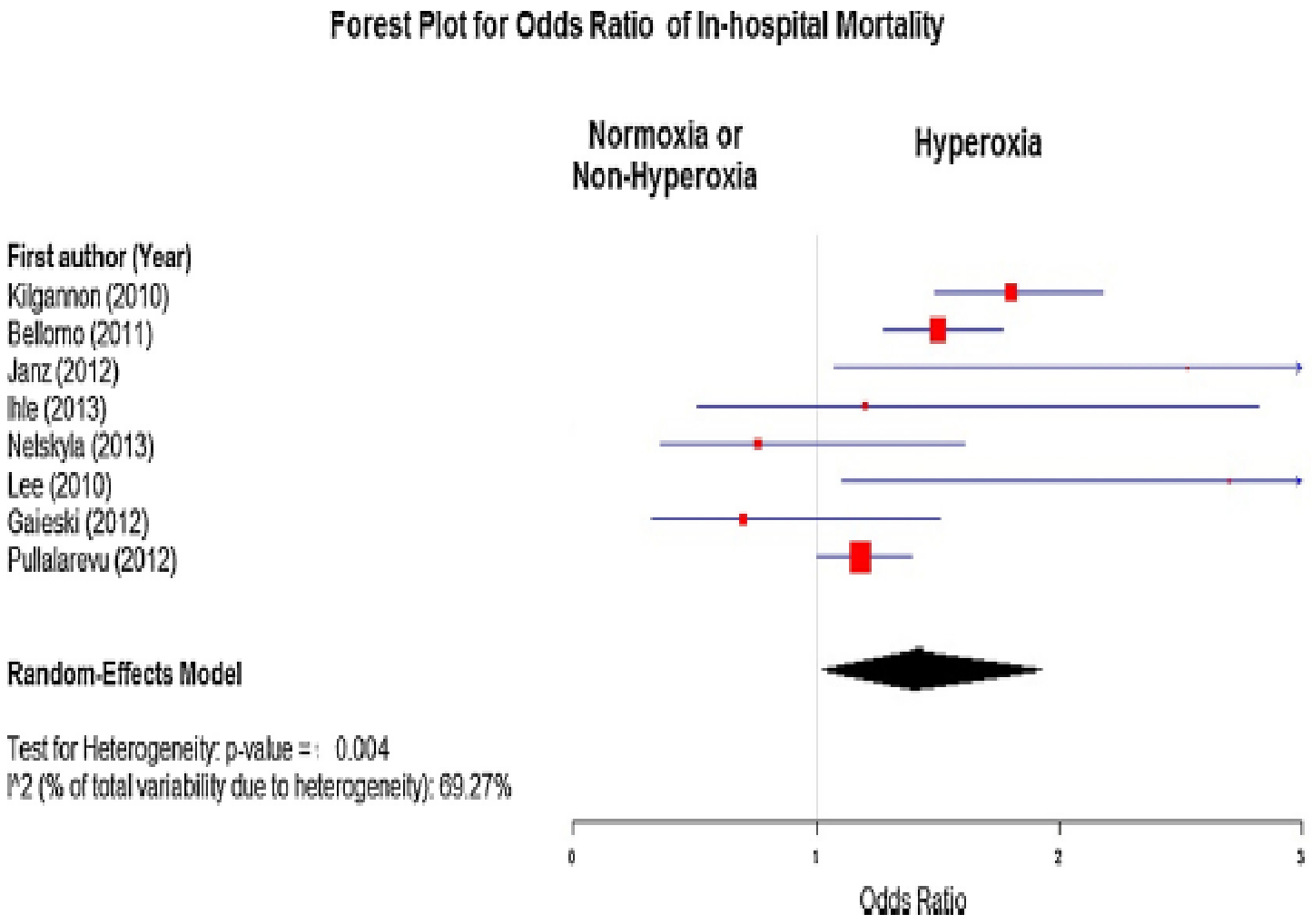


**Fig. 2.** Forest plot for odds ratios of in-hospital mortality.

Helmerhorst et al. Critical Care (2015) 19:348
DOI 10.1186/s13054-015-1067-6

CRITICAL CARE

RESEARCH Open Access

# Associations of arterial carbon dioxide and arterial oxygen concentrations with hospital mortality after resuscitation from cardiac arrest

Hendrik J. F. Helmerhorst[1,2*], Marie-José Roos-Blom[3,4], David J. van Westerloo[1], Ameen Abu-Hanna[3], Nicolette F. de Keizer[3,4] and Evert de Jonge[1,4]

**Abstract**

**Introduction:** Arterial concentrations of carbon dioxide ($PaCO_2$) and oxygen ($PaO_2$) during admission to the intensive care unit (ICU) may substantially affect organ perfusion and outcome after cardiac arrest. Our aim was to investigate the independent and synergistic effects of both parameters on hospital mortality.

**Methods:** This was a cohort study using data from mechanically ventilated cardiac arrest patients in the Dutch National Intensive Care Evaluation (NICE) registry between 2007 and 2012. $PaCO_2$ and $PaO_2$ levels from arterial blood gas analyses corresponding to the worst oxygenation in the first 24 h of ICU stay were retrieved for analyses. Logistic regression analyses were performed to assess the relationship between hospital mortality and both categorized groups and a spline-based transformation of the continuous values of $PaCO_2$ and $PaO_2$.

**Results:** In total, 5,258 cardiac arrest patients admitted to 82 ICUs in the Netherlands were included. In the first 24 h of ICU admission, hypocapnia was encountered in 22 %, and hypercapnia in 35 % of included cases. Hypoxia and hyperoxia were observed in 8 % and 3 % of the patients, respectively. Both $PaCO_2$ and $PaO_2$ had an independent U-shaped relationship with hospital mortality and after adjustment for confounders, hypocapnia and hypoxia were significant predictors of hospital mortality: OR 1.37 (95 % CI 1.17–1.61) and OR 1.34 (95 % CI 1.08–1.66). A synergistic effect of concurrent derangements of $PaCO_2$ and $PaO_2$ was not observed ($P = 0.75$).

**Conclusions:** The effects of aberrant arterial carbon dioxide and arterial oxygen concentrations were independently but not synergistically associated with hospital mortality after cardiac arrest.

# Survival curve of $PaCO_2$

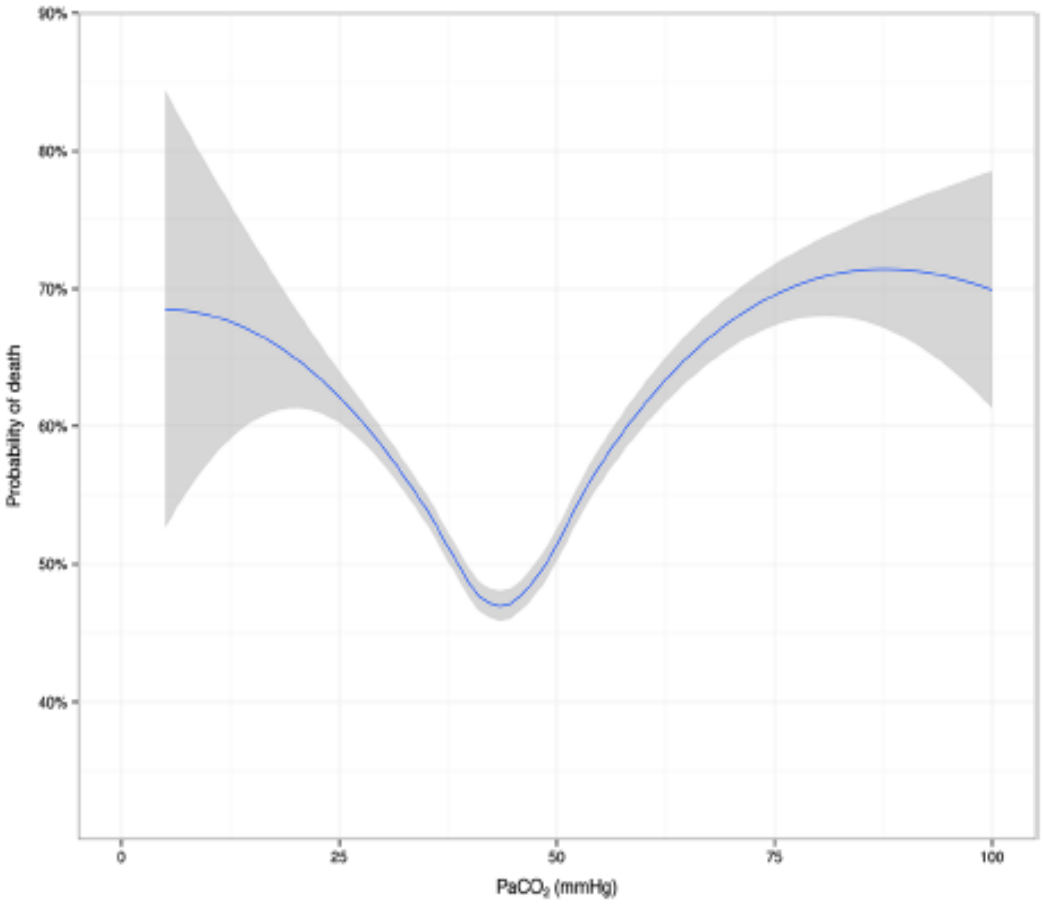


**Fig. 1** Adjusted probability of in-hospital death by arterial carbon dioxide levels. Loess smoothing curve predicted from logistic regression model adjusted for spline functions of age, lowest glucose, AP4-adj and $PaO_2$. Grey zones represent 95 % confidence intervals

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# Survival curve of $PaO_2$

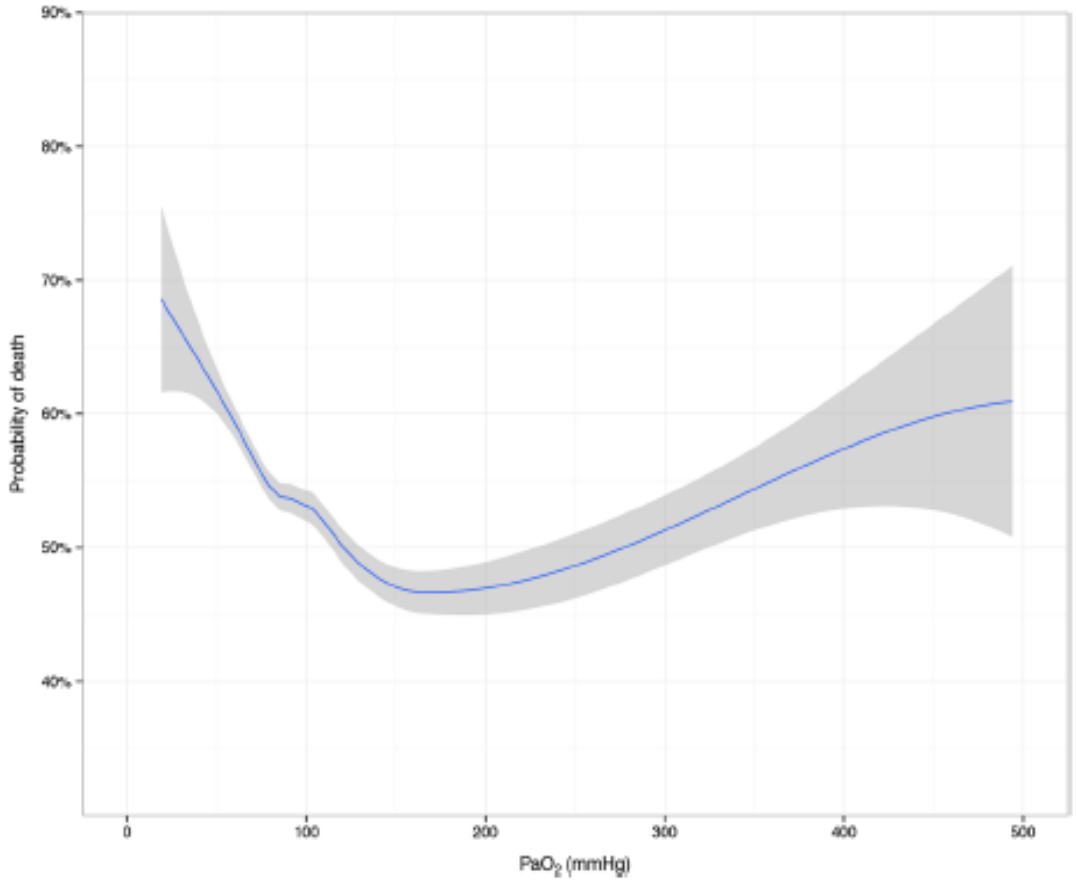


**Fig. 2** Adjusted probability of in-hospital death by arterial oxygen levels. Loess smoothing curve predicted from logistic regression model adjusted for spline functions of age, lowest glucose, AP4-adj and $PaCO_2$. Grey zones represent 95 % confidence intervals

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# Hemodynamic and ventilation in post cardiac arrest

- If possible MAP should be 70-80 after ROSC to improve survival and neurological outcome
- Optimum $PaO_2$(100-200) and $PaCO_2$ (35-45) improve survival
- Most common complication after ROSC if infection and multiorgan failure that TTM may help to decrease multiorgan failure but not to be zero

# Q & A