New opportunities to save lives from cardiac arrest

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Speaker disclosures

Research Funding:	NIH – NHLBI R18 Philips Healthcare Stryker Corporation Medtronic Foundation
Advisory Board:	HeartSine Corporation Velomedix Corporation
Volunteer:	American Heart Assoc. Sudden Cardiac Arrest Assoc.

Cardiac arrest: introduction

Cardiac arrest epidemiology in the US

400,000 arrests / year

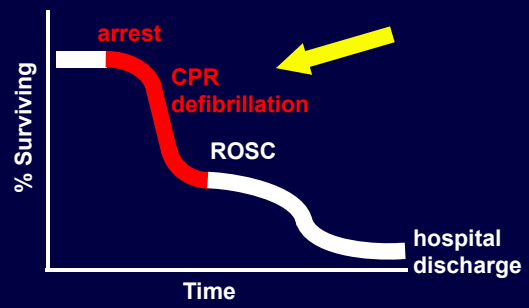
2 / 3 Out-of-hospital

1 / 3 In-hospital

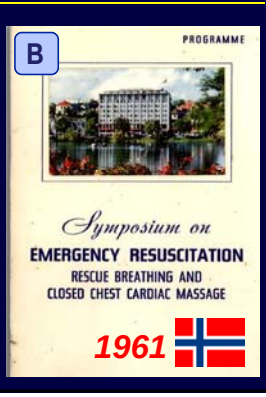
1-5% survival to hospital discharge **10-20%**

Seattle: 10-20%!

Mortality from cardiac arrest



Approaching 50 years of modern CPR



A. Peter Safar, 1950s

B. Early symposium on CPR

Cardiac arrest: fundamentals of therapy

"Chain of Survival"

Prompt Access | Early CPR | Early Defib | ACLS Care

ACLS Provider Manual (American Heart Association)

Chest compression alone CPR

Bystander contacted 9-1-1

standard CPR (n=279) | chest compression alone (n=241)

29/279 (10.4%) | 35/241 (14.6%)

p=0.18

Improvement due to:
? less time to train
? better CPR strategy

Hallstrom et al, 2000

Chest compression alone CPR: revisited


ORIGINAL ARTICLE

CPR with Chest Compression Alone or with Rescue Breathing

Thomas D. Rea, M.D., Carol Fahrenbruch, M.S.P.H., Linda Culley, B.A., Rachael T. Donohoe, Ph.D., Cindy Hambly, E.M.T., Jennifer Innes, B.A., Megan Bloomingdale, E.M.T., Cleo Subido, Steven Romines, M.S.P.H., and Mickey S. Eisenberg, M.D., Ph.D.

2010

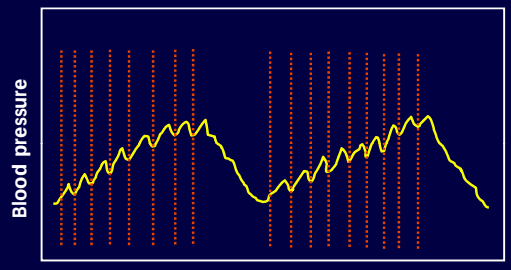
Bystander contacted 9-1-1

standard CPR (n=960) | chest compression alone (n=981)

11.5% | 14.4% (OR 2.9)

Survival to DC

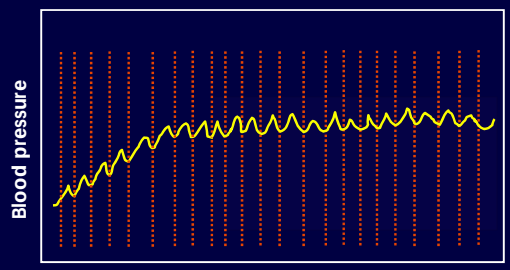
Standard CPR vs CC alone



= chest compression

Berg et al, 2001

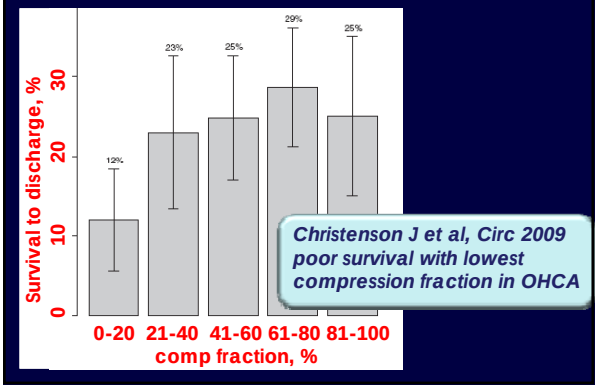
Standard CPR vs CC alone



= chest compression

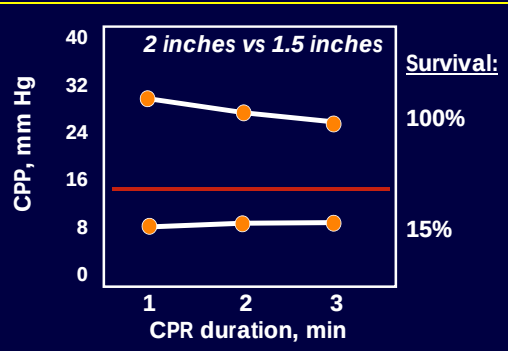
Berg et al, 2001

"No flow" / compression fraction



Christenson J et al, Circ 2009 poor survival with lowest compression fraction in OHCA

Chest compression depth



ICCM, 2005

CPR first may improve survival

Influence of cardiopulmonary resuscitation prior to defibrillation in patients with out-of-hospital ventricular fibrillation

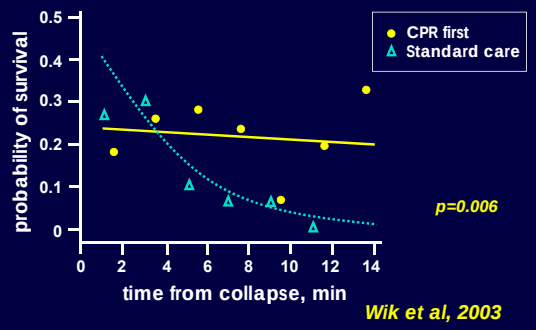
24% (155/639) 30% (142/478) *p=0.04*

Defib first - AHA — 42 months

CPR (90 sec) first, then defib — 36 months

Cobb et al, 1999

CPR first may improve survival: RCT



p=0.006

Wik et al, 2003

CPR sensing and recording defibrillator

Similar defibrillators now made by both Philips and Zoll

Using CPR feedback to improve quality

Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: A prospective interventional study☆

Jo Kramer-Johansen[a,b,c,*], Helge Myklebust[d], Lars Wik[a,c,e], Bob Fellows[f], Leif Svensson[g], Hallstein Sørebø[c], Petter Andreas Steen[a,h]

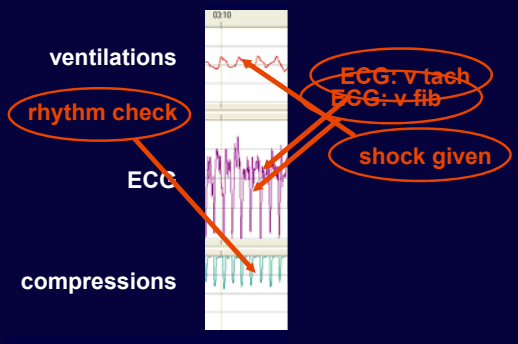
Kramer Johansen, 2006

CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system☆

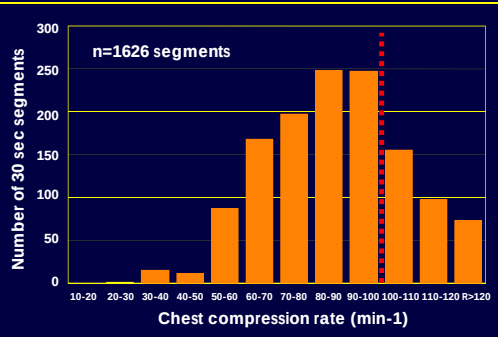
Benjamin S. Abella[a,*], Dana P. Edelson[b], Salem Kim[a], Elizabeth Retzer[c], Helge Myklebust[d], Anne M. Barry[c], Nicholas O'Hearn[e], Terry L. Vanden Hoek[c], Lance B. Becker[a]

Abella, 2007

Actual arrest transcript: U of C, 2004

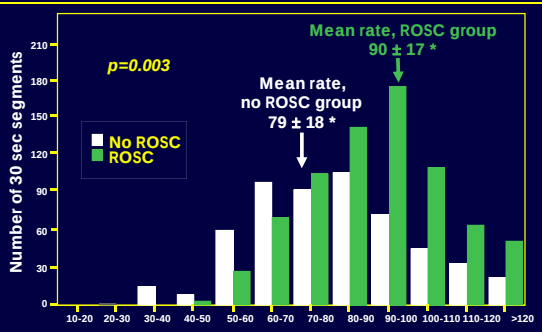


Chest compression rates



Abella et al, 2005

Chest compression rates by survival



Abella et al, 2005

CPR renaissance: measuring CPR

Interruptions of Chest Compressions During Emergency

Terence D. V
Marc D. Berg

Quality of Cardiopulmonary Resuscitation During Out-of-Hospital Cardiac Arrest

Lars Wik, MD; PhD
Jo Kramer-Johansen, MD

Context Cardiopulmonary resuscitation (CPR) guidelines recommend target values for compressions, ventilations, and CPR-free intervals allowed for rhythm analysis and

Quality of Cardiopulmonary Resuscitation

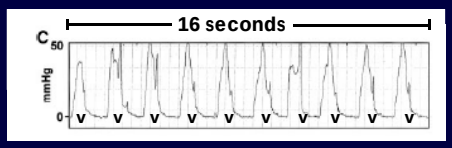
D

Hyperventilation-Induced Hypotension During Cardiopulmonary Resuscitation

Tom P. Aufderheide, MD; Gardar Sigurdsson, MD; Ronald G. Pirrallo, MD, MHSA; Demetris Yannopoulos, MD; Scott McKnite, BA; Chris von Briesen, BA, EMT; Christopher W. Sparks, EMT; Craig J. Conrad, RN; Terry A. Provo, BA, EMT-P; Keith G. Lurie, MD

Valenzuela et al, Circ 2005
Wik et al, JAMA 2005
Abella et al, JAMA 2005
Aufderheide et al,Circ 2004

Hyperventilation during EMS resuscitation

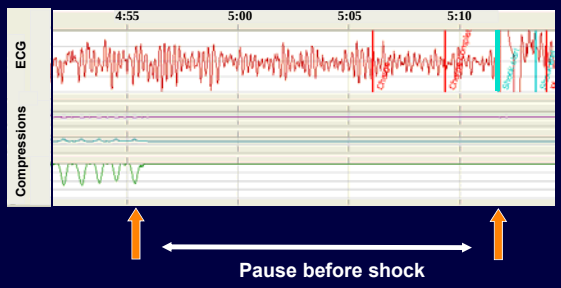


mean ventilation rate: 30 ± 3.2

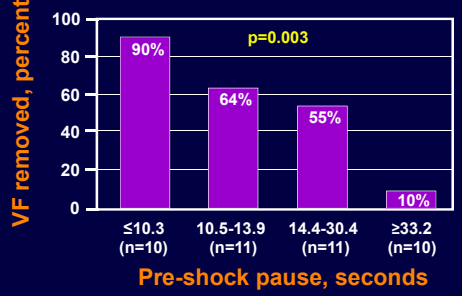
first group: 37 ± 4 → after retraining: 22 ± 3

Aufderheide et al, 2004

Chest compression pauses before shocks

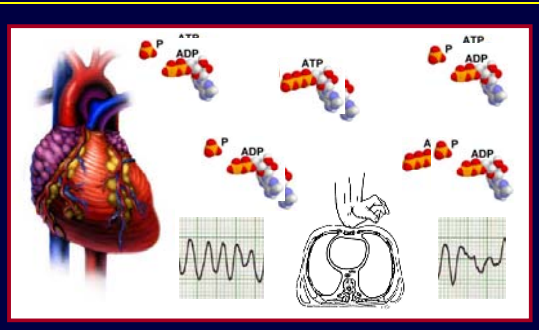


Dose-effect of pre-shock pauses

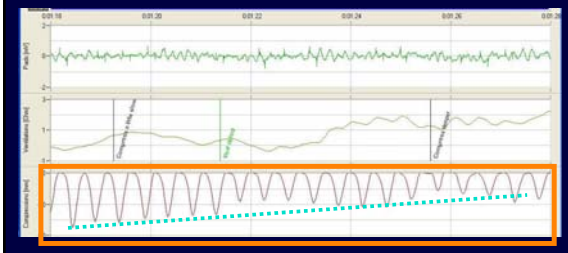


Edelson et al, 2006

Possible model underlying these data

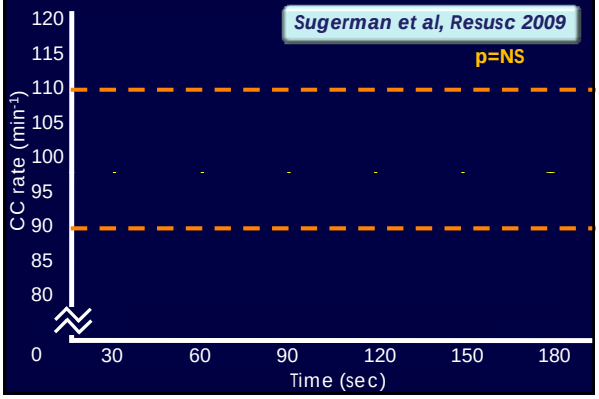


Additional rescuer factor: fatigue

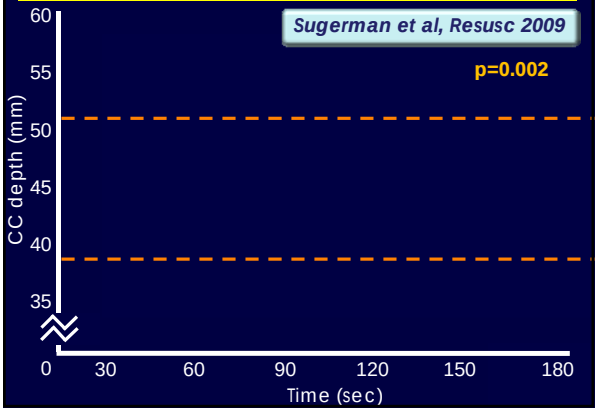


May represent fatiguing

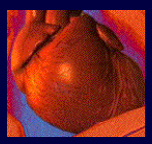
Mean CC rate over consecutive 30 sec segments



Mean CC depth over consecutive 30 sec segments



Current CPR quality: summary



1. **Slow compression rates**
2. **Frequent and lengthy pauses**
3. **Shallow compressions**
4. **Hyperventilation**

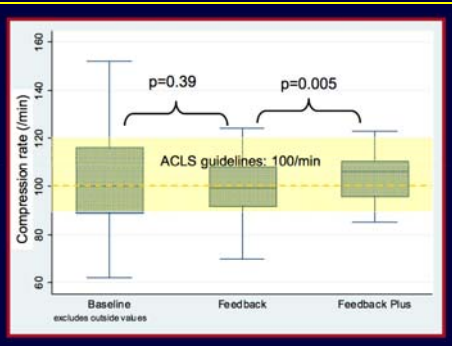
The problem with cardiac arrest

The military solution

Debriefing intervention

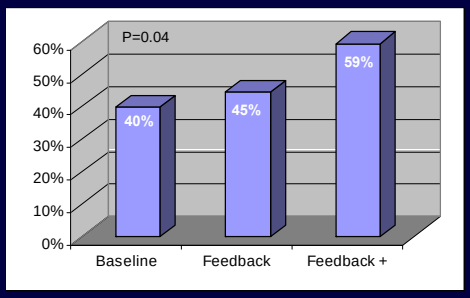
- Code review investigation:
  - All residents and students rotating through resuscitation team roles
  - Debrief teams on their events
  - Weekly 30-45 min resuscitation debriefing/teaching sessions

Median compression rate by group



Edelson et al, 2008

Return of spontaneous circulation



Edelson et al, 2008
Training effect confirmed by Dine et al. 2008

CPR quality technologies

Manual CPR support devices

Zoll AED, R series

Philips MRx

Mechanical CPR devices

Zoll Autopulse

LUCAS

Autopulse data

Ong et al, 2006

Out-of-hospital, Richmond, VA (one site)

	Manual	Autopulse
ROSC	101/499 (20.2%)	96/278 (34.5%)
Admitted	54/485 (11.1%)	58/277 (20.9%)
D/C	14/486 (2.9%)	27/278 (9.7%)

Autopulse data: RCT

Hallstrom et al, 2006 (ASPIRE)

Out-of-hospital, multicenter RCT – US, Canada

	Manual	Autopulse
ROSC	92/373 (24.7%)	104/394 (26.4%)
D/C	37/373 (9.9%)	23/394 (5.8%)

CPR in the workplace

Friday, June 13, 2008

Tim Russert, TV correspondent

Known asymptomatic coronary dz

Suffered AMI → cardiac arrest

Attempted resuscitation (CPR and defibrillation) failed

Unknown CPR quality or pre-shock pause time

CPR in the home

Friday, June 25, 2009

Michael Jackson died at home

Respiratory arrest from drug OD

Attempted resuscitation (CPR and defibrillation) failed

CPR performed in the bed – questionable quality, pauses in performance?

Improving EMS care with "CC only"


Minimally Interrupted Cardiac Resuscitation by Emergency Medical Services for Out-of-Hospital Cardiac Arrest

Bentley J. Bobrow, MD
Lani L. Clark, BS

Context Out-of-hospital cardiac arrest is a major public health problem.
Objective To investigate whether the survival of patients with out-of-hospital car-

Bobrow et al, 2008

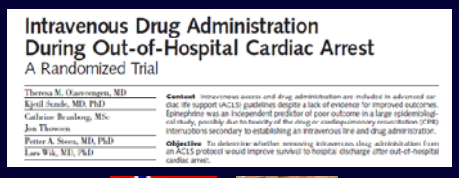
Interventions:

1. **Significantly delay intubation**
2. **200 compressions before first shock**
3. **Minimize pre and post shock pauses**

Tripled survival to hospital discharge (3.8% → 9.1%)

The key importance of CPR

Reflected in the poor impact of ACLS meds:


Intravenous Drug Administration During Out-of-Hospital Cardiac Arrest
A Randomized Trial

Theresa M. Olasveengen, MD
Kjetil Sunde, MD, PhD
Catherine Brunborg, MSc
Jon Thowsen
Petter A. Steen, MD, PhD
Lars Wik, MD, PhD

Context Intravenous access and drug administration are included in advanced cardiac life support (ACLS) guidelines despite a lack of evidence for improved outcomes. Epinephrine was an independent predictor of poor outcome in a large epidemiological study, possibly due to toxicity of the drug or cardiopulmonary resuscitation (CPR) interruptions secondary to establishing an intravenous line and drug administration.

Objective To determine whether removing intravenous drug administration from an ACLS protocol would improve survival to hospital discharge after out-of-hospital cardiac arrest.

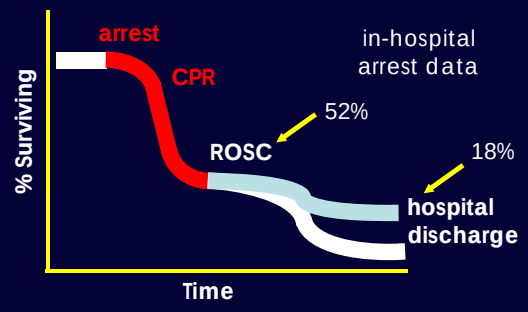
2009

Randomized trial of epinephrine versus no epinephrine For EMS treated cardiac arrest → NO SURVIVAL BENEFIT!

Key "take home" points – part 1

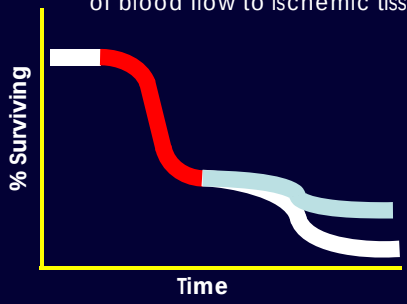
1. **Cardiac arrest is not hopeless!**
2. **CPR quality has big impact**
3. **Minimize ventilations**
4. **Maximize chest compression rate and depth**
5. **Consider CPR feedback tools and code debriefing**
6. **Use hypothermia after cardiac arrest**

The post-arrest problem

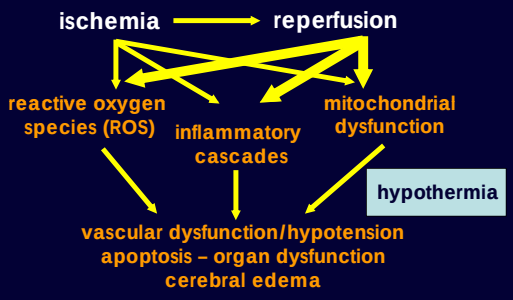


Reperfusion injury

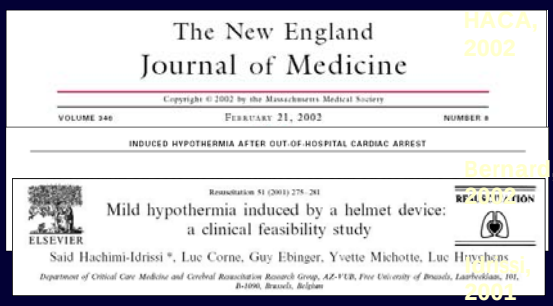
Damage observed after restoration of blood flow to ischemic tissues



Hypothermia mechanisms



Modern era of hypothermia use


The New England Journal of Medicine

VOLUME 346 FEBRUARY 21, 2002 NUMBER 8

INDUCED HYPOTHERMIA AFTER OUT-OF-HOSPITAL CARDIAC ARREST

Resuscitation 51 (2001) 275–281

Mild hypothermia induced by a helmet device: a clinical feasibility study

Said Hachimi-Idrissi *, Luc Corne, Guy Ebinger, Yvette Michotte, Luc Huyghens

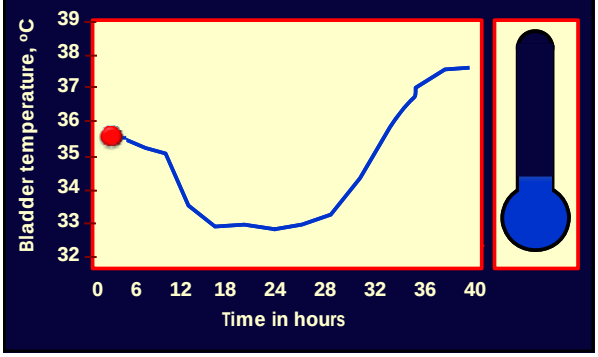
HACA, 2002

Bernard, [illegible], 2001

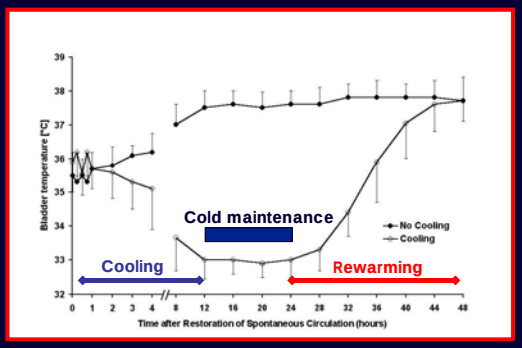
Modern era of hypothermia use

	Age (years)	Female sex (%)	VF (#)	ROSC (min)	Target temp (°C)	Duration (hours)	Method
HACA	59 (51-68)	65 (24)	254 (92%)	22 (16-30)	33	24	Cool air
Bernard	68 (57-75)	25 (32)	77 (100%)	24 (17-32)	33	12	Ice packs
Idrissi	74 (66-79)	13 (39)	0 -	33 (27-37)	34	Up to 4	Helmet

What cooling looks like



Modern era of hypothermia use



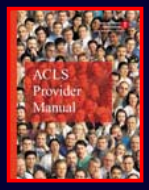
HACA, 2002

Hypothermia trials: outcomes

	Hypothermia (%)	Normothermia (%)	RR (95% CI)	P value
Alive at hospital discharge with favourable neurological recovery				
HACA	72/136 (53%)	50/137 (36%)	1.51 (1.14-1.89)	0.006
Bernard	21/43 (49%)	9/34 (26%)	1.75 (0.99-2.43)	0.052
Idrissi	4/16 (25%)	1/17 (6%)	4.25 (0.70-53.83)	0.16
Alive at 6 months with favourable neurological recovery				
HACA	71/136 (52%)	50/137 (36%)	1.44 (1.11-1.76)	0.009

Hypothermia in the guidelines

AHA Guidelines 2005 conference
Dallas, January 22-29, 2005
Several hundred cardiac arrest experts
Closed meeting, rigorous process



CPR/BLS/ACLS guidelines underwent revision

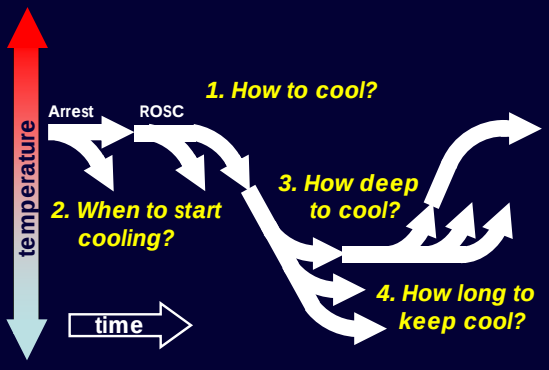
New guidelines released supporting hypothermia, published 11/2005

Hypothermia in the guidelines 2010

Comatose out-of-hospital VF:
Class I recommendation

In-hospital arrest, other rhythms:
Class IIb recommendation

Practical issues of cooling



How to cool?

Ice packs, cooling blankets, catheters…

How to cool?

University of Chicago Hospitals (UCH) initial experience (2003-4):

cooling blanket and/or ice packing

Advantages: cheap, non-invasive, 'off the shelf'

Disadvantages: slow cooling, can be messy, lack of thermostatic control

Difficulties with ice bag cooling

Merchant RM et al, 2006

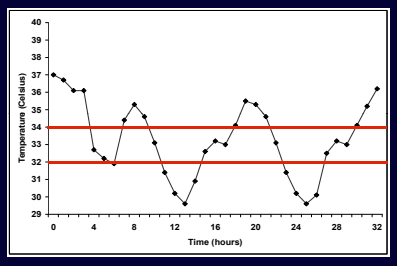
Retrospective chart review of cooling cases From three hospitals (2 in U.S., 1 in U.K.)

Found 20/32 cases (63%) were overcooled

Trends towards better outcome in non-overcooled pts

Suggests need for thermostatic feedback control

Surface cooling in the real world



Merchant RM et al, 2006

Simple cooling methods

Induced hypothermia using large volume, ice-cold intravenous fluid in comatose survivors of out-of-hospital cardiac arrest: a preliminary report

Stephen Bernard[a,b,*], Michael Buist[a], Orlando Monteiro[a], Karen Smith[b]

Bernard S et al, 2003

Study in 22 post-arrest patients
Infused 30 ml/kg ice cold saline
Average temperature drop of 1.5 °C

Remember: 1. No maintenance or rewarming
2. Large fluid load (safety unproven)

Is cold saline enough?

Cold infusions alone are effective for induction of therapeutic hypothermia but do not keep patients cool after cardiac arrest☆ **2007**

Andreas Kliegel[a], Andreas Janata[a], Cosima Wandaller[a], Thomas Uray[a], Alexander Spiel[b], Heidrun Losert[a], Matthias Kliegel[c], Michael Holzer[a], Moritz Haugk[a], Fritz Sterz[a,*], Anton N. Laggner[a]

Cooling was fast … But maintenance was hard

65% cooled to target within 60 minutes

77% failed to stay cool during course

Real world usage: Switzerland

From evidence to clinical practice: Effective implementation of therapeutic hypothermia to improve patient outcome after cardiac arrest☆ **2006**

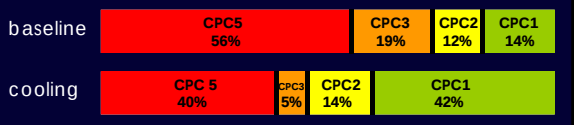
Mauro Oddo, MD; Marie-Denise Schaller, MD; François Feihl, MD; Vincent Ribordy, MD; Lucas Liaudet, MD

Oddo M et al, 2006

Retrospective study at one hospital in Switzerland
Cooling intervention with historical controls
Survivors of out-of-hospital arrest (n=109)
Cooling initially via ice bags, then cooling mattress
Target temperature 33°C, maintained for 24 hrs
All post-arrest ST elevations received cardiac cath

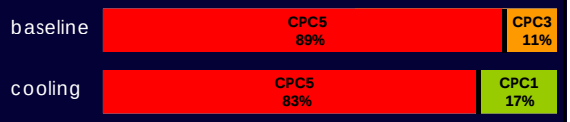
Real world usage: Switzerland

Outcome at discharge for out-of-hospital VF arrest



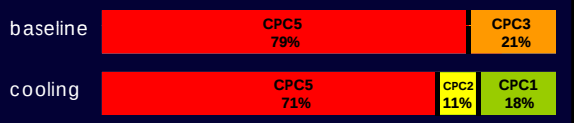
Real world usage: Switzerland

Outcome at discharge for out-of-hospital asystole arrest



Real world usage: Switzerland

Outcome at discharge for all rhythms with post-arrest hypotension and shock



Compilation of recent experiences

Therapeutic hypothermia after cardiac arrest in clinical practice: Review and compilation of recent experiences **2009**

Emily Sagalyn, MD; Roger A. Band, MD; David F. Gaieski, MD; Benjamin S. Abella, MD, MPhil

Author	n HC	n TH	Survival Historical Control n (%)[a]	Survival Therapeutic Hypothermia n (%)	OR	95% CI
Arrich et al (17)	123	462	39 (32)	267 (58)	2.9	1.9–4.6
Bellard et al (21)	36	32	13 (36)	18 (56)	2.3	0.8–6.8
Busch et al (14)	34	27	11 (32)	16 (59)	3.0	0.9–9.9
Oddo et al (13)	54	55	20 (37)	28 (51)	1.8	0.8–3.8
Schefold et al (30)	31	31	21 (70)	21 (70)	1.0	.3–2.9
Sunde et al (18)	58	61	18 (31)	34 (56)	2.8	1.2–6.4
Combined ORs					2.5	1.8–3.3

Hypothermia clinical benefit is robust (consistent across Numerous studies)

hypothermia registry data

(a) Adverse events: all 34 centres and (b) adverse events: 22 reporting centers.

	n = 986
(a)	
Bradycardia <40 beats/min	127 (13)
Tachycardia >130 beats/min	57 (6)
Atrial fibrillation	88 (9)
VT	89 (9)
VF	71 (7)
Any combination of arrhythmia	325 (33)
Pneumonia	407(41)
Sepsis	35 (4)
Other infection	41 (4)
Bleeding requiring transfusion	44 (4)
Intracerebral bleeding	5 (0.5)
Seizures	233 (24)

Nielsen et al, 2009

Infection and seizures are common

Bradycardia (13%)
Significant bleed (4%)

More than just hypothermia

Post-arrest care is a critical care "bundle":

- **Therapeutic hypothermia**
- Careful hemodynamic management
- Coronary intervention if STEMI or high probability of coronary cause
- Neurology consultation and assessment

Hypothermia resource website

http://www.med.upenn.edu/resuscitation/hypothermia/index.shtml

Prognostication: who will wake up?

Can BIS be helpful to prognosticate?:

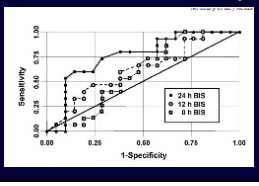
Neurologic prognostication and bispectral index monitoring after resuscitation from cardiac arrest☆

Marion Leary[a], David A. Fried[a], David F. Gaieski[a], Raina M. Merchant[a], Barry D. Fuchs[b], Daniel M. Kolansky[c], Dana P. Edelson[d], Benjamin S. Abella[a,b,*]

[a] Center for Resuscitation Science and Department of Emergency Medicine, University of Pennsylvania, Philadelphia, USA
[b] Section of Pulmonary, Allergy and Critical Care, University of Pennsylvania, Philadelphia, USA
[c] Section of Cardiology, University of Pennsylvania, Philadelphia, USA
[d] Section of Hospital Medicine, University of Chicago, Chicago, USA

2010

Answer: somewhat helpful, but not completely



BIS before 24 hrs – not very useful

BIS at 24 hours – more useful

What's hot: cooling and PCI

Coronary angiography and intervention during hypothermia can be performed safely without cardiac arrhythmia or vasospasm

Ralf Koester · Jan Kaehler · Achim Barmeyer · Kai Müllerleile · Marion Priefler · Gerold Soeffker · Stephan Braune · Axel Nierhaus · Thomas Meinertz · Stefan Kluge

2011

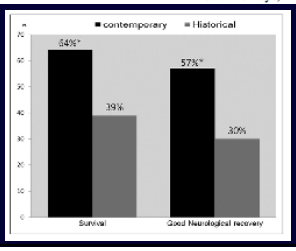
Bottom line: little risk of arrythmia, bleeding or Vasospasm during TH catheterzation

What's hot: cooling and PCI

Usefulness of Cooling and Coronary Catheterization to Improve Survival in Out-of-Hospital Cardiac Arrest

Dion Stub, MBBS[a,b,*], Christopher Hengel, MBBS[a], William Chan, MBBS[a,b], Damon Jackson, MBBS[a], Karen Sanders, RN, GradDipEd[a], Anthony M. Dart, BA, BM, BCh, DPhil[a,b], Andrew Hilton, MBBS[c], Vincent Pellegrino, MBBS[c], James A. Shaw, MBBS, PhD[a,b], Stephen J. Duffy, MBBS, PhD[a], Stephen Bernard, MBBS, MD[c], and David M. Kaye, MBBS, PhD[a,b]

2011



Less than 40% of patients had STEMI; yet huge Survival benefits when OHCA patients cathed

Big remaining question: What about IHCA?

Hypothermia in the news

USA TODAY

December 10, 2006

Life saved at Medtronic offices via AED, cooling

Witnessed arrest, received bystander CPR, underwent cooling

Full neurologic recovery

Hypothermia in the news

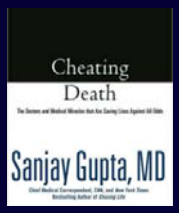
Popular Science

January, 2009

"Freezing the Heart to Save the Life"

Good graphics showing effects of cooling

Hypothermia in the news



2009 - 2010

CNN television documentary and book
Features a number of arrest survivors

The future: regionalized care?

Regional Systems of Care for Out-of-Hospital Cardiac Arrest *2010*
A Policy Statement From the American Heart Association

Graham Nichol, MD, MPH, FAHA, Chair; Tom P. Aufderheide, MD, FAHA; Brian Eigel, PhD; Robert W. Neumar, MD, PhD; Keith G. Lurie, MD; Vincent J. Bufalino, MD, FAHA; Clifton W. Callaway, MD, PhD; Venugopal Menon, MD, FAHA; Robert R. Bass, MD; Benjamin S. Abella, MD, MPhil; Michael Sayre, MD; Cynthia M. Dougherty, PhD, FAHA;

American Heart Association supportive of concept; no national coordination or established system for this …

Arizona has system In place – "cardiac arrest centers"

NYC is doing this too

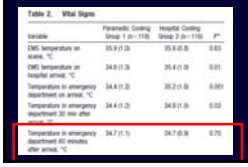
EMS cooling?

Induction of Therapeutic Hypothermia by Paramedics After Resuscitation From Out-of-Hospital Ventricular Fibrillation Cardiac Arrest
A Randomized Controlled Trial *2010*

Stephen A. Bernard, MD; Karen Smith, BSc, PhD; Peter Cameron, MD; Kevin Masci; David M. Taylor, MD; D. James Cooper, MD; Anne-Maree Kelly, MD; William Silvester, MB, BS; for the Rapid Infusion of Cold Hartmanns (RICH) Investigators*

Bottom line: no survival benefit to cooling in the field with chilled saline

WHY?

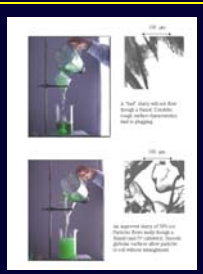


If you were cooled in field or in ED, same temp at 60 minutes post arrival …

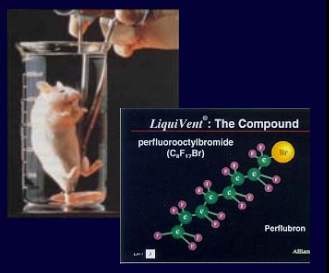
Technologies for EMS use?

Specialized cooling pads **Evaporative cooling tools**

Faster cooling technologies on horizon?



Ice slurry technology



Perfluorocarbons

Boot camp course for post-arrest care

Hypothermia and Resuscitation Training

Philadelphia – next course
March 14-15, 2013

Intensive two day CME course in hypothermia methods, protocols, and applications

Designed for critical care, cardiology or emergency medicine physicians and nurse leaders

Offers "hypothermia certification"

Workshop design – small course size – held quarterly

Hands on simulations

Expert faculty proctors

Honoring survivors and rescuers

Interactive learning

Brain cooling in action

Ben Abella, MD

Ben Bobrow, MD

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Kelsey Sheak
Marisa Cinousis
David Buckler

Center for Resuscitation Science
Penn Emergency Medicine

Questions?

It's never too early to improve your resuscitation care!