Advances in Resuscitation Science

September 23, 2016

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Minneapolis, Minnesota

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Disclosures

Dr. Lurie is a practicing cardiac electrophysiologist, a medical researcher at University of Minnesota and Hennepin County Medical Center, and a consultant for ZOLL Medical.

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Saving the Brain During CPR and After ROSC

4

The Science of Resuscitation

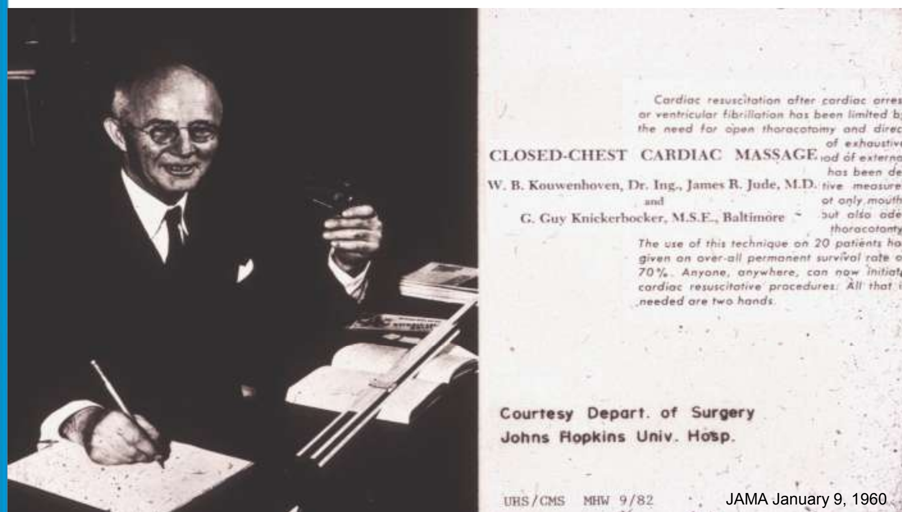
- Historical perspectives
- Status quo update
- What’s new?
- A peek at the future

5

Cardiac Arrest Today

- Leading cause of death in the U.S.
  - > 350,000 out of hospital
  - > 350,000 in hospital
  - Average age: 66 years old

6



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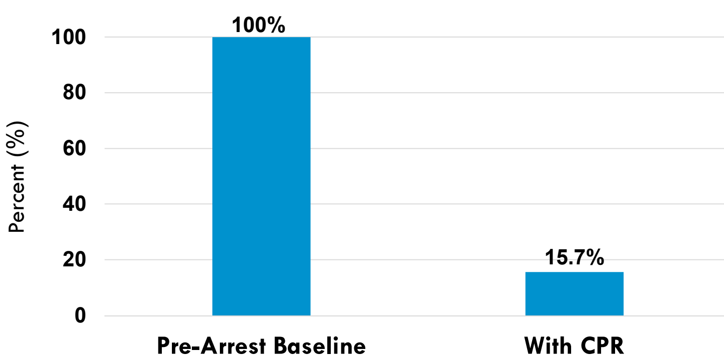
Cardiac Output During Standard CPR



Duggal et al. J Appl Physiol 1993;74(1):147-152.

Cardiac output under best conditions limited during standard CPR

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Standard CPR

- Standard CPR (S-CPR) is the cornerstone of resuscitation care; usually first option
- S-CPR provides 25-33% normal blood flow to the heart and brain
- Inadequate blood flow to the heart and brain contributes to the high mortality rates

S-CPR remains the cornerstone of resuscitation care; essentially unchanged for > 50 years

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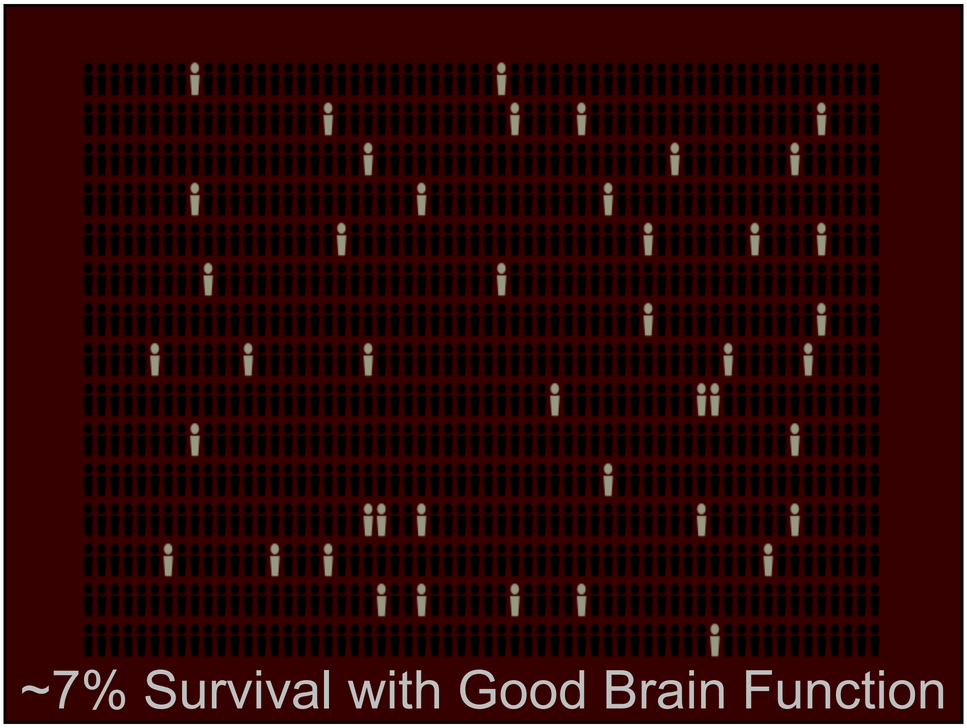
Status Quo Update

10



Inherent Limitations of Standard CPR

- Blood flow is limited
- Difficult to perform correctly without feedback tools
- Initial reintroduction of blood flow may cause injury
- Increases arterial and venous pressures simultaneously which may cause head injury

These limitations must be overcome to improve outcomes

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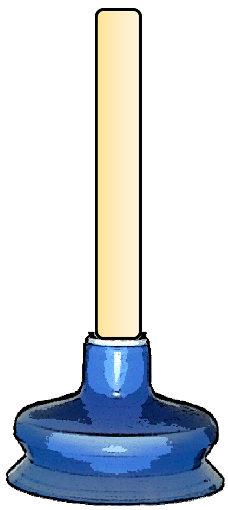
What Does Success Look Like?

13

>30% Survival with Good Brain Function

Index Case 1987



- Saved by a Household Plunger
- San Francisco General Hospital

CPR: The P Stands for Plumber's Helper.
Lurie et al - *JAMA* 1990

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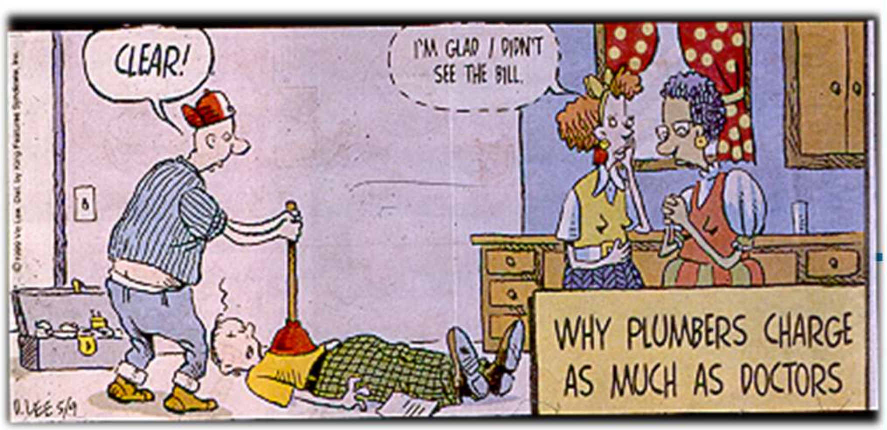
JAY LENO
FIRST NIGHT



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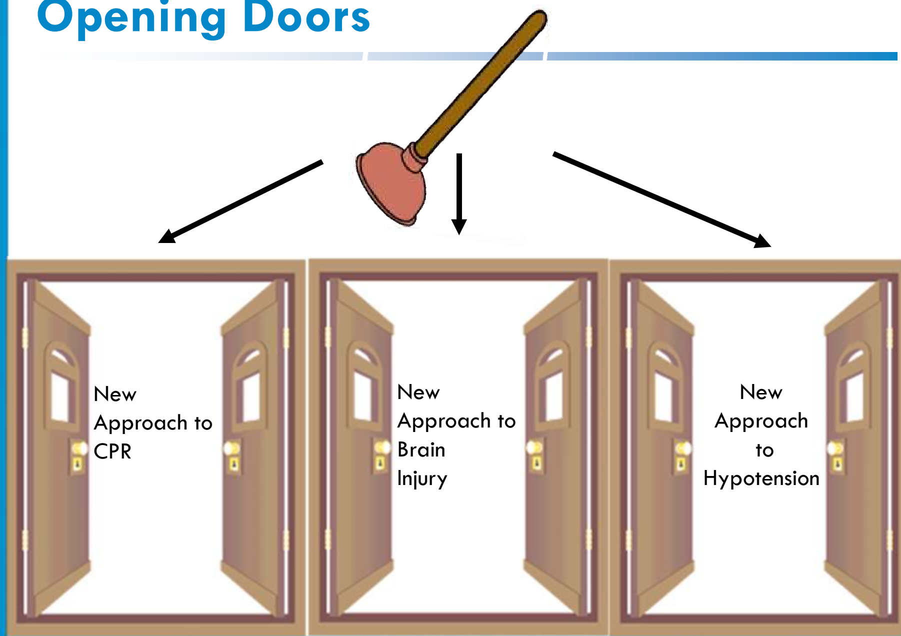
Opening Doors



Improving Flow

Harnessing the Intrathoracic Pump

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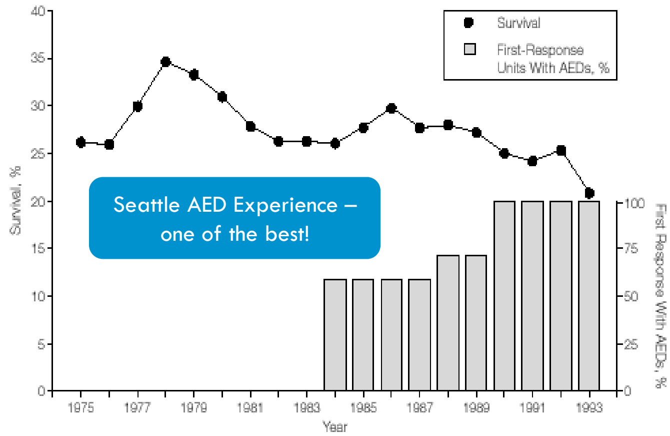
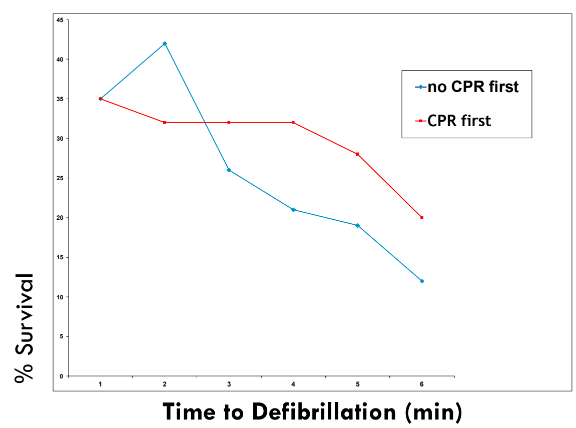
Despite More AEDs, Survival Rates Remain Low



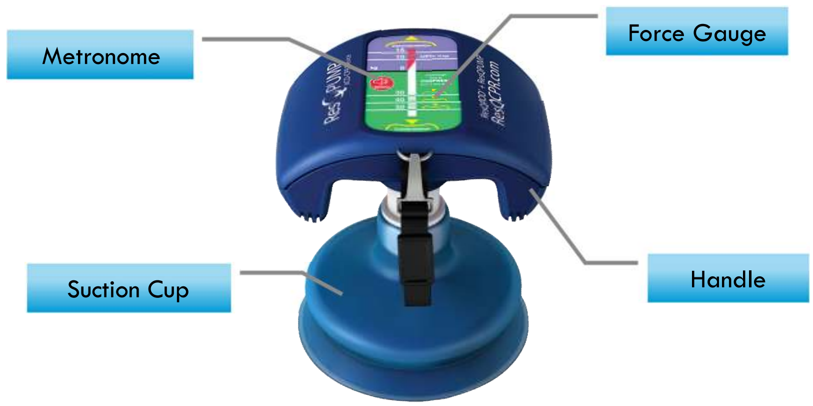
Cobb et al. JAMA 1999

Influence of CPR Prior to Defibrillation After Out-of-Hospital Ventricular Fibrillation

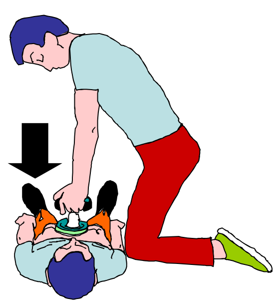


Cobb et al. JAMA
281:1182, 1999

Active Compression Decompression (ACD) CPR

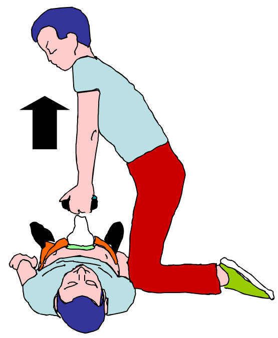


Compression



Compress to recommended depth (e.g., 2 inches)

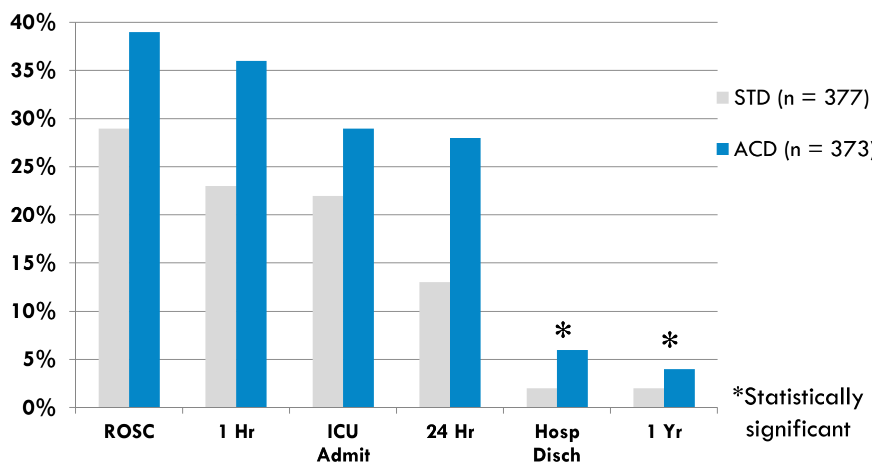
Decompression



Decompress with up to 20 lbs (10 kg) of lift

Randomized Clinical Trial (Paris, France)

Survival After Cardiac Arrest



Plaisance P et al. A comparison of standard CPR and ACD resuscitation for out-of-hospital cardiac arrest. *N Engl J Med.* 1999;341:569-75.

Was something missing with ACD CPR by itself?

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The Impedance Threshold Device is Born

26

Founding Concept

Each time the chest wall recoils following a compression, the impedance threshold device (ITD) transiently blocks air/oxygen from entering the lungs, creating a small vacuum in the chest, resulting in improved cardiac preload.

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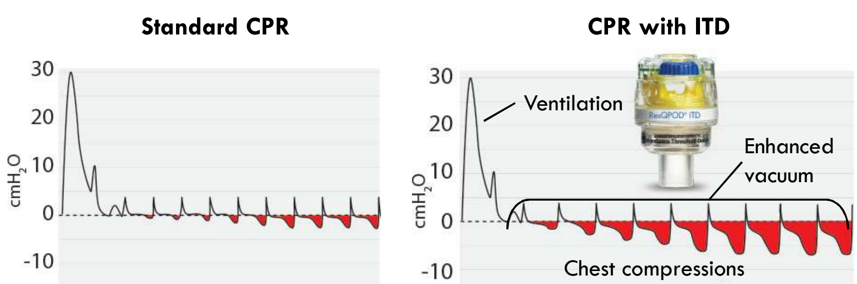
How does it work?

Greater vacuum (negative pressure) in the chest during chest wall recoil leads to increased venous return and circulation and lower ICP



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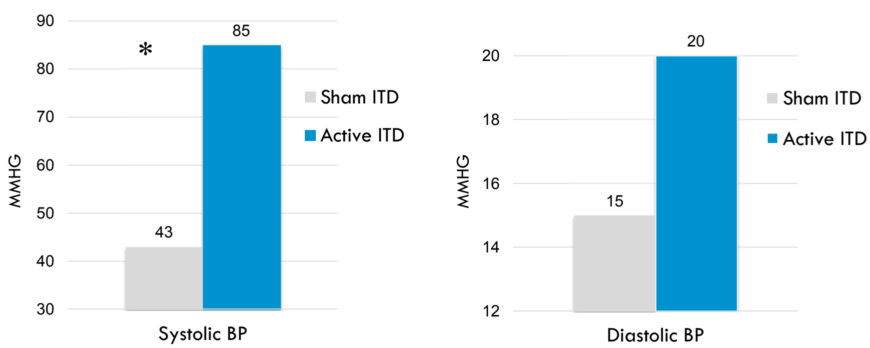
Using an ITD

Human Data
Blood Pressure during Conventional CPR +/- ITD

Milwaukee, WI



*p<0.05

BP after 14 Minutes of ITD Use

n = 22

Pirrallo et al. *Resuscitation* 2005;66:13-20.

No Silver Bullet for Sudden Cardiac Arrest

- Improved circulation is not enough
- High quality CPR is essential
- A systems-based approach is key

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CPR Quality Affects Outcomes

A decade of mistakes

A long detour….

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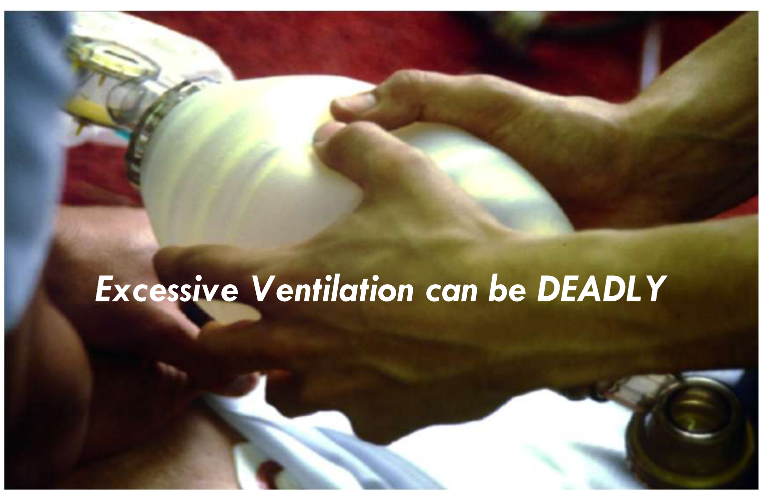
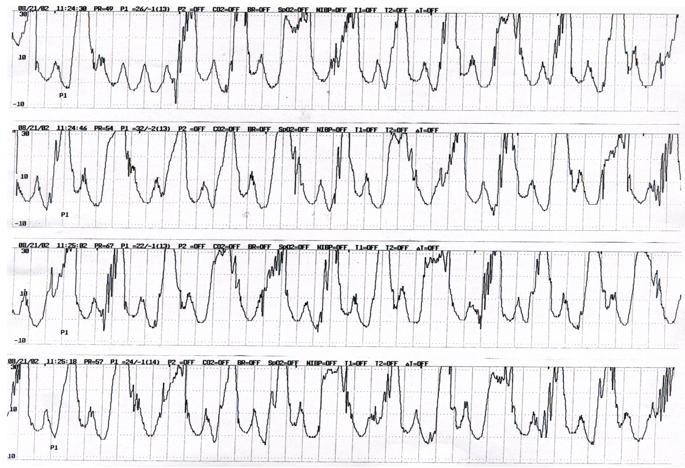
What is High Quality CPR?

Ventilation Strategies

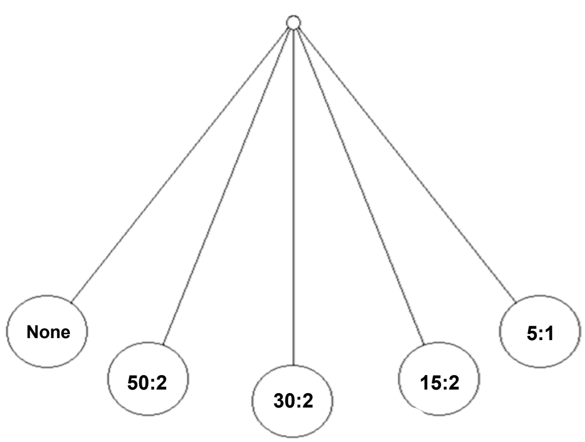


Death by Hyperventilation

Ventilation rate: 47/min



Lots of Ventilation Options



Improving EMS with "CC" Only CPR

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

Bentley J. Bobrow, MD
Lani L. Clark, BS
Gordon A. Ewy, MD

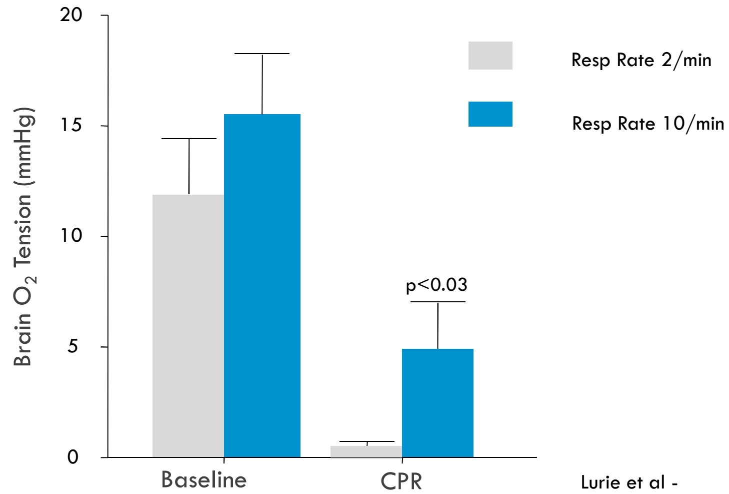
Context Out-of-hospital cardiac arrest is a major public health problem.
Objective To investigate whether the survival of patients with out-of-hospital cardiac arrest would improve with minimally interrupted cardiac resuscitation (MICR), an

- Interventions:
  1. Significantly delay intubation
  2. 200 compressions before first shock
  3. Minimize pre and post shock pauses
  4. Primary focus on compressions, secondary focus ventilation
- **Tripled survival to hospital discharge (3.8% → 9.1%)**

Bobrow et al – JAMA 2008

How Important is Mouth-to-Mouth?

2 vs 10: Effect on Brain O2 Tension



Lurie et al -
Resp Care 2008

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30:2 vs Continuous Compressions for BLS?

Nichol et al, NEJM 2015

Intervention: CCC with asynchronous breaths @ 10/min
Control: 30:2

No reported statistically significant difference in outcomes (hospital discharge with favorable neurological function):

CCC – 7%
30:2 – 7.7%

P=0.09

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Whoooo

Not so fast….

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Outcomes in Patients Included in the Primary Analysis

Table 3. Outcomes in Patients Included in the Primary Analysis.*

Outcome	Intervention Group (N=12,653)	Control Group (N=11,058)	Adjusted Difference (95% CI)	P Value
Effectiveness population				
Primary outcome: survival to discharge — no./total no. (%)	1,129/12,613 (9.0)	1072/11,035 (9.7)	−0.7 (−1.5 to 0.1)	0.07
Transport to hospital — no. (%)	6686 (52.8)	6066 (54.9)	−2.0 (−3.6 to −0.5)	0.01
Return of spontaneous circulation at ED arrival — no./total no. (%)	3,058/12,646 (24.2)	2799/11,051 (25.3)	−1.1 (−2.4 to 0.1)	0.07
Admission to hospital — no./total no. (%)	3,108/12,653 (24.6)	2860/11,058 (25.9)	−1.3 (−2.4 to −0.[illegible]	0.03
Survival to 24 hr — no./total no. (%)	2,816/12,614 (22.3)	2569/11,031 (23.3)	−1.0 (−2.1 to 0.2)	0.10
Hospital-free survival — days†	1.3±5.0	1.5±5.3	−0.2 (−0.3 to −0.1)	0.004
Discharge home — no./total no. (%)	844/12,613 (6.7)	794/11,034 (7.2)	−0.5 (−1.2 to 0.2)	0.15
Modified Rankin scale score‡				
≤3 — no./total no. (%)	883/12,560 (7.0)	844/10,995 (7.7)	−0.6 (−1.4 to 0.1)	0.09
Mean	5.63±1.29	5.60±1.35	0.04 (0.0 to 0.08)	0.04
Distribution — no./total no. (%)				
0	320/12,560 (2.5)	336/10,995 (3.1)	—	—
1	271/12,560 (2.2)	222/10,995 (2.0)	—	—
2	147/12,560 (1.2)	161/10,995 (1.5)	—	—
3	145/12,560 (1.2)	125/10,995 (1.1)	—	—
4	97/12,560 (0.8)	103/10,995 (0.9)	—	—
5	98/12,560 (0.8)	87/10,995 (0.8)	—	—
6	11,482/12,560 (91.4)	9961/10,995 (90.6)	—	—
Adjusted analyses of primary outcome				
Adjusted for study site	—	—	−0.6 (−1.3 to 0.1)	0.09
Adjusted for age	—	—	−0.7 (−1.5 to 0.1)	0.07
Adjusted for sex	—	—	−0.7 (−1.5 to 0.1)	0.07
Adjusted for public location	—	—	−0.7 (−1.4 to 0.1)	0.09
Adjusted for bystander-witnessed	—	—	−0.6 (−1.4 to 0.[illegible]	0.18
Adjusted for bystander-initiated CPR	—	—	−0.7 (−1.5 to 0.0)	0.07
Adjusted for duration until EMS arrival	—	—	−0.7 (−1.5 to 0.[illegible]	0.07
Adjusted for all the above covariates	—	—	−0.3 (−1.1 to 0.4)	0.38
Additional analyses of primary outcome				
Analysis including multiple imputation — %	9.0	9.8	−0.7 (−1.5 to 0.1)	0.07
Prespecified per-protocol analysis				
Treatment determined by automated algorithm — no./total no. (%)	497/6529 (7.6)	353/3678 (9.6)	−2.0 (−2.9 to −1.1)	<0.001
Adjusted [illegible]	—	—	[illegible]	0.04
Post hoc per-protocol analysis: treatment determined by coordinator assessment — no./total no. (%)	834/9649 (8.6)	606/6156 (9.8)	−1.2 (−2.0 to −0.4)	<0.01
Safety population				
Total no.	14,065	12,015		
Survival to discharge — no. (%)	1273 (9.1)	1152 (9.6)	−0.5 (−1.3 to 0.2)	0.15

* Plus–minus values are means ±SD. Differences between percent values are shown in percentage points. Difference, confidence intervals, and P values for the analysis in the effectiveness population were adjusted for cluster and sequential monitoring; other analyses were adjusted for cluster only. Data on hospital-free survival were missing for 92 patients in the intervention group and 70 in the control group, and

Nichol G et al. N Engl J Med 2015;373:2203-2214.

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† Hospital-free survival was defined as the number of days alive and permanently out of the hospital during the first 30 days after the cardiac

Survival with Favorable Brain Function

CCC – 7.6%

30:2 – 9.6%

P<0.001

Nichol G et al. N Engl J Med 2015;373:2203-2214.

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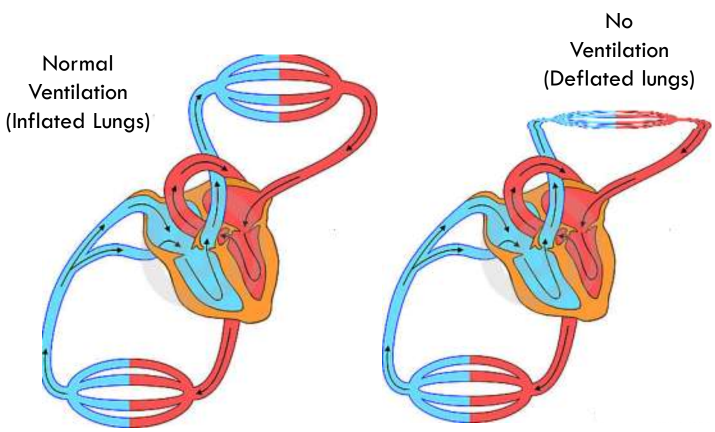
Effect of No Ventilation



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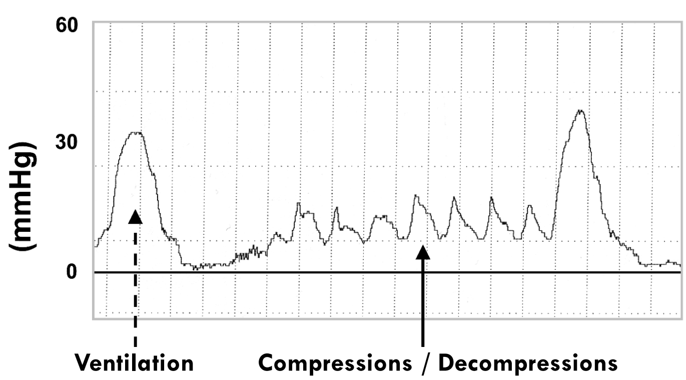
Importance of Complete Recoil



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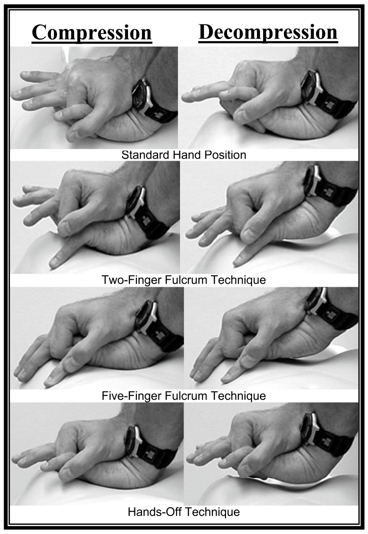
Chest Compression & Release



Aufderheide et al
Resuscitation 2005

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Does the rate of Chest Compression Release Velocity Effect Survival?

YES!

Resuscitation 92 (2015) 107–114

Contents lists available at ScienceDirect

Resuscitation

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

ELSEVIER

EUROPEAN RESUSCITATION COUNCIL

Clinical paper

Chest compression release velocity: Association with survival and favorable neurologic outcome after out-of-hospital cardiac arrest☆,☆☆

Alexander Kovacs[a], Tyler F. Vadeboncoeur[b], Uwe Stolz[c], Daniel W. Spaite[c], Taro Irisawa[d], Annemarie Silver[e], Bentley J. Bobrow[a,c,f,*]

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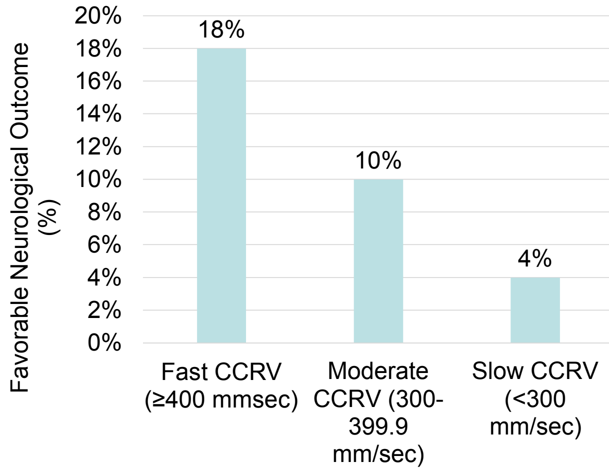
[b] Department of Emergency Medicine, Mayo Clinic Florida, 4500 San Pablo Road, Jacksonville, FL 32224, United States
[c] Department of Emergency Medicine, University of Arizona, PO Box 245057, 1501 N. Campbell, Tucson, AZ 85724-5057, United States
[d] Department of Traumatology and Acute Critical Care, Osaka University Hospital, 2-15 Yamadaoka, Suita, Osaka 565-0871, Japan
[e] Zoll Medical Corporation, 269 Mill Rd, Chelmsford, MA 01824, United States
[f] Bureau of Emergency Medical Services and Trauma System, Arizona Department of Health Services, 150 N. 18th Avenue, #540, Phoenix, AZ 85007-3248, United States

Favorable Neurological Outcome Significantly Associated with Chest Compression Release Velocity



P<0.001

Outcome Results from Improved BLS and ALS, Including ITD Use

	Control	Intervention	P-value	Odds Ratio (95% CI)
ROSC	30.4% (535/1757)	34.1% (586/1719)	0.022	1.18 (1.022, 1.366)
Hospital Discharge	9.7% (170/1757)	12.6% (216/1719)	0.007	1.34 (1.078, 1.671)
HD (VF)	19.0% (85/447)	31.1% (128/412)	<0.001	1.91 (1.384, 2.667)
CPC 1 or 2	31.4% (11/35)	55.2% (32/58)	0.033	2.68 (1.027, 7.213)

Survival with good brain function significantly improved with high quality CPR and use of ITD

Aufderheide et al. Heart Rhythm 2010

Resuscitation Outcomes Consortium (ROC) PRIMED

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Trial of an Impedance Threshold Device in Out-of-Hospital Cardiac Arrest

Tom P. Aufderheide, M.D., Graham Nichol, M.D., Thomas D. Rea, M.D.,
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for the Resuscitation Outcomes Consortium (ROC) Investigators

Results: Of 8718 patients included in the analysis, 4345 were randomly assigned to treatment with a sham ITD and 4373 to treatment with an active device. **A total of 260 patients (6.0%) in the sham-ITD group and 254 patients (5.8%) in the active-ITD group met the primary outcome (P=0.71).**

Conclusions: Use of the ITD did not significantly improve survival with satisfactory function among patients with out-of-hospital cardiac arrest receiving standard CPR.

N Engl J Med 2011;365:798-806.

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CPR Quality Affects Outcomes

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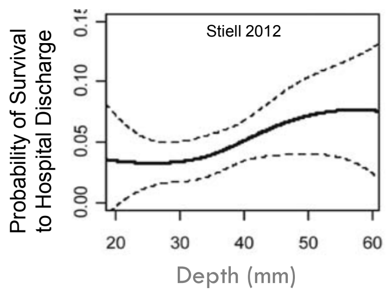
Variable Quality of Conventional CPR

Wide variations in practice even in some of the best EMS systems

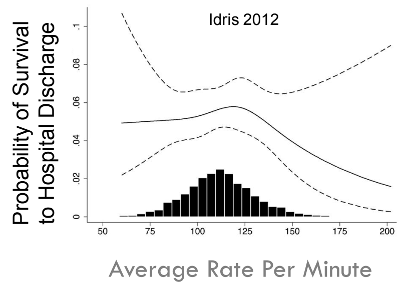
(data from NIH-funded Resuscitation Outcomes Consortium - ROC)

Variable compression depth and rate limit blood flow and worsens outcomes

Compression Depth



Compression Rate



Variations in CPR quality strongly linked to outcomes

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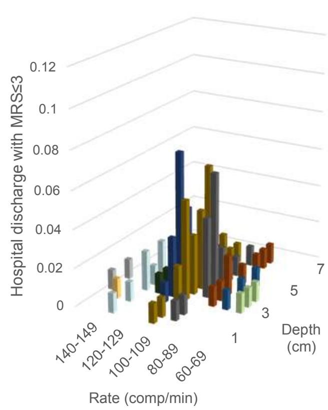
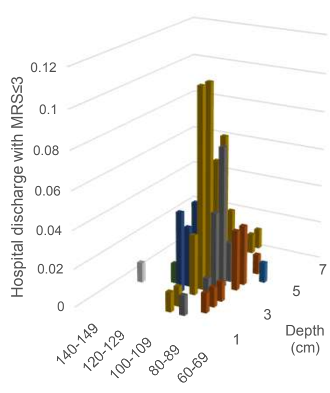
Survival with Good Brain Function (ROC PRIMED)
Correct Rate and Depth are CRITICAL

Survival with MRS≤3 (Sham)



Survival with MRS≤3 (Active)



Yannopoulos et al 2015

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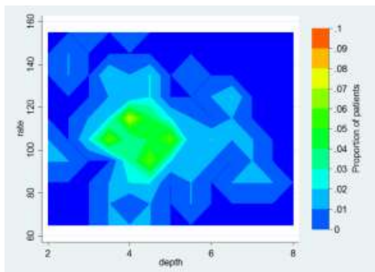
The Sweet Spot for Neurologically-Sound Survival

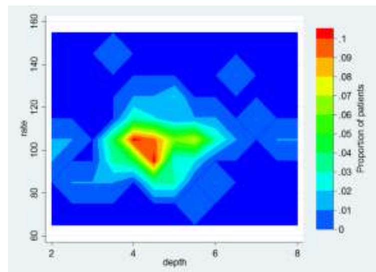
(Contour plots of all ROC survivors using proportion of good survivors in each cell and canonical analysis for optimization)

Sham ITD



Rate = 108 cpm
Depth = 4.6 cm

Active ITD

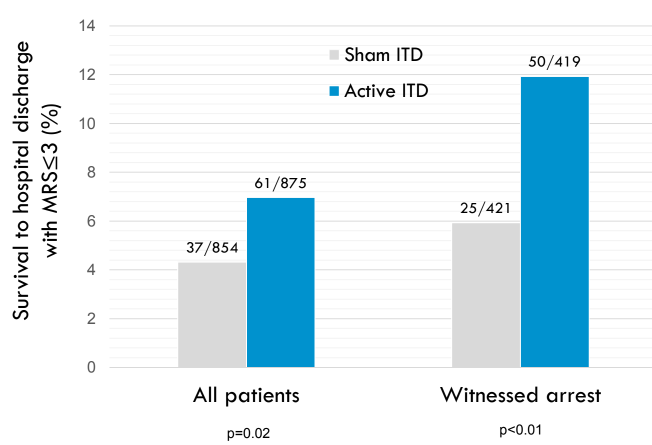


Rate = 106 cpm
Depth = 4.8 cm

Sugiyama et al, 2016

Lessons from ROC PRIMED: Subjects who received Quality CPR

(rate 80-120/minute; depth 4-6 cm; fraction ≥50%)



Yannopoulos et al AHA 2014

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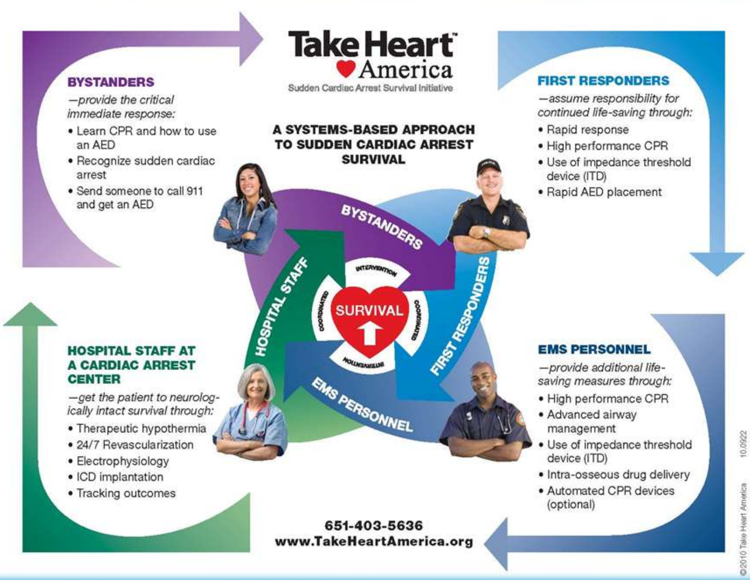
Métronome

High Quality CPR

- Essential for saving lives
- To be performed well, rate (100-110), depth (2”), and release monitoring and feedback is needed
- Devices such as the ITD need high-quality CPR to work
- Training and feedback to rescue personnel are essential
- Automated CPR devices also provide sustained, high quality CPR

Better circulation is needed but often not enough

Take Heart America



Meet Ben

- Bystander CPR (mom)
- AED (first responders)
- ITD & high quality CPR (Allina EMS)
- Hypothermia (Mercy Medical Center)
- ICD (Mercy Medical Center)
- Now: Marketing @ Medtronic

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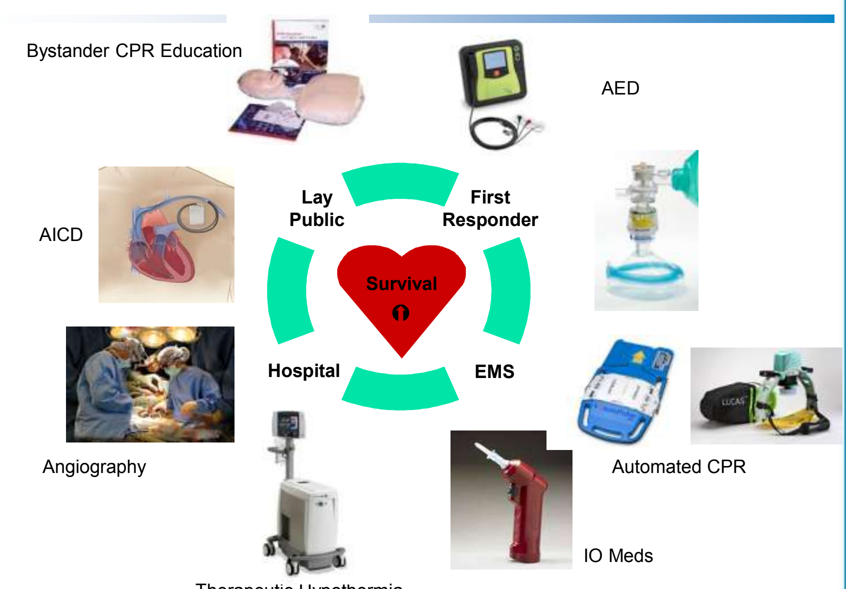
Transformative Technologies



Results from Take Heart America

Outcome	Control (N =1063)	Intervention (N = 247)	OR (95% CI)	P-value
ROSC	40 (38%)	116 (47%)	1.46 (0.90, 2.40)	0.129
Hospital discharge: All patients	**9 (8.5%)**	**48 (19%)**	**2.60 (1.19, 6.26)**	**0.011**
CPC Score	1.63 ± 0.52	1.38 ± 0.70	N/A	0.341

Survival rates with good brain function doubled with AHA-recommended transformative technologies

Lick et al. Crit Care Med 2010

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Implementation of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital Cardiac Arrest Improves Patient Survival and Neurological Outcome

Christy L. Hopkins, MD; Chris Burk, NREMT-P; Shane Moser, AAS; Jack Meersman, NREMT-P; Clair Baldwin, NREMT-P; Scott T. Youngquist, MD, MSc

Introduction—Survival from out-of-hospital cardiac arrest (OHCA) varies by community and emergency medical services (EMS) system. We hypothesized that the adoption of multiple best practices to focus EMS crews on high-quality, minimally interrupted cardiopulmonary resuscitation (CPR) would improve survival of OHCA patients in Salt Lake City.
Methods and Results—In September 2011, Salt Lake City Fire Department EMS providers underwent a systemwide restructuring of care for OHCA patients that focused on the adoption of high-quality CPR with minimal interruptions and offline medical review of defibrillator data and feedback on CPR metrics. Victims were directed to ST-elevation myocardial infarction receiving centers.

Prospectively collected data on patient survival and neurological outcome for all OHCAs were compared.

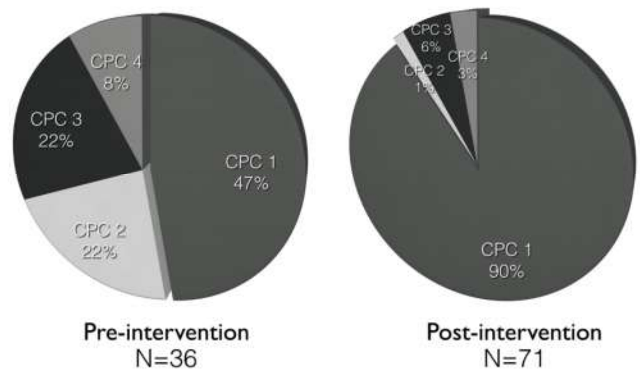
In the postintervention period, there were 407 cardiac arrests with 65 neurologically intact survivors (16%), compared with 330 cardiac arrests with 25 neurologically intact survivors (8%) in the preintervention period.

Conclusions—A multifaceted protocol, including several American Heart Assocation best practices for the resuscitation of patients with OHCA, was associated with improved survival and neurological outcome.

(J Am Heart Assoc. 2016;5:e002892
doi: 10.1161/JAHA.115.002892)

Key Words: cardiac arrest • emergency medical services

Implementation of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital Cardiac Arrest Improves Patient Survival and Neurological Outcome



How Long Should We Perform CPR?

Automated CPR Plays an Important Role in Transport

- Transport (AHA recommended)
- Prolonged resuscitations (rescuer fatigue)
- Helps maintain high quality CPR
- Understaffed crews
- Cath lab

Autopulse

LUCAS

Thumper Michigan Instrumental Life-Stat

Defibtech Lifeline ARM

High Quality CPR

68 Minutes with Automated CPR + ITD

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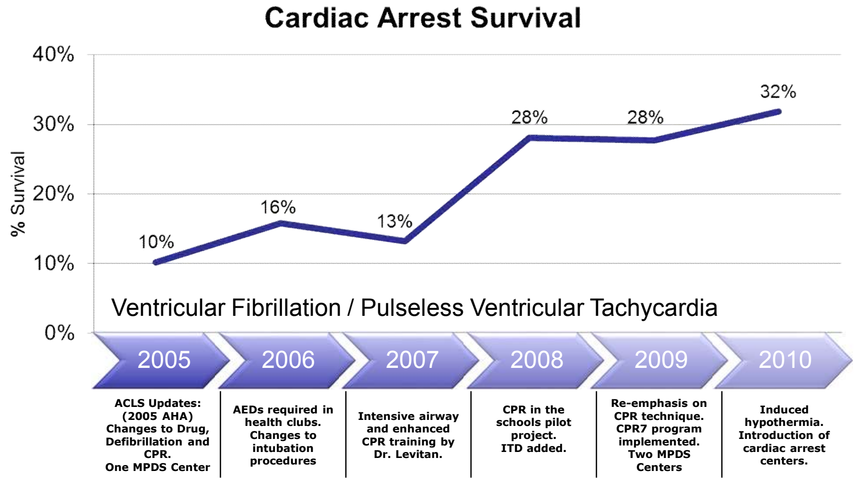
Compliance

Challenge

Opportunity

Systems Approach to Cardiac Arrest in Alameda County, CA



Enhancements for Prehospital Cardiac Arrest Resuscitation

Sporer, et al. Prehospital Emergency Care 2016

Compliance is a Challenge

	Full Bundle (ITD, automated CPR, and TH)	No Bundle (No ITD, no automated CPR, no TH)	p-value
Overall Survival to Hospital Discharge			
All rhythms	**37.8%** (34/90)	**12.1%** (132/1090)	<0.001
VF	**62.5%** (20/32)	**29.1%** (60/206)	<0.001
Non-VF	**24.1%** (14/58)	**8.1%** (72/884)	<0.001
Survival to Hospital Discharge with CPC≤2			
All rhythms	**25.3%** (21/83)	**6.9 %** (72/1051)	<0.001
VF	**51.7%** (15/29)	**23.4 %** (46/197)	0.004
Non-VF	**11.1%** (6/54)	**3.0 %** (26/854)	0.054

Only 10% of patients were treated with the full bundle

What's Next?

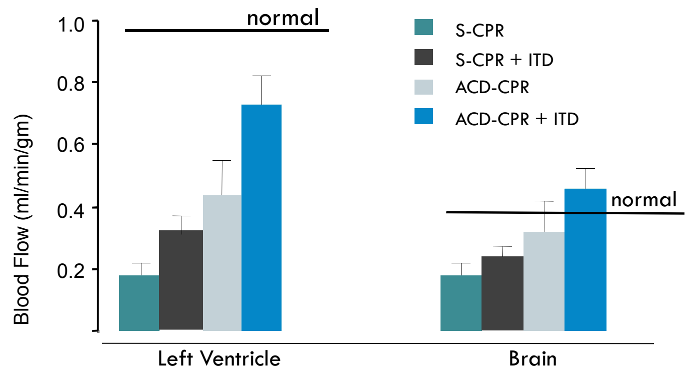
ResQTrial: 2 CPR Methods

Standard CPR (S-CPR) versus **ACD-CPR + ITD (ACD+ITD)**

versus

Blood Flow to Heart and Brain

Porcine V-Fib Model



ACD+ITD work synergistically to achieve desired effect

Lurie et al. Circulation 1995;91:1629-32 (ACD +/- ITD) and Lurie et al. J Cardio Electrophysiology 1997;8(5):584-600

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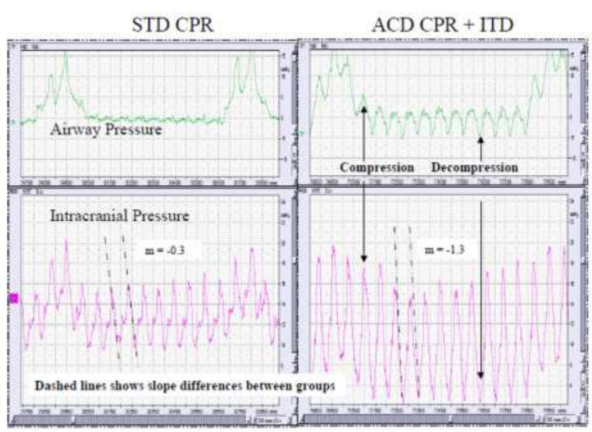
Mechanism of Benefit

ACD+ITD lowers ICP faster and for a longer duration during CPR



Metzger et al. Critical Care Medicine, 2012

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Mechanism of ACD-CPR + ITD
(from pig studies)

- Lowers intrathoracic pressure
- Enhances venous return to right heart
- Lowers ICP
- Increases cerebral and coronary perfusion and circulation

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Prior ACD+ITD Human Trials

Four European clinical trials in out-of-hospital cardiac arrest (OHCA) subjects showed that ACD+ITD:

1. Augmented hemodynamics and circulation (ACD +/- ITD)
   n=21 subjects; Plaisance et al., *Circulation* 2000;101:989
2. Lowered intrathoracic pressures (ACD +/- ITD: facemask vs. ET tube)
   n=13 subjects; Plaisance et al., *Critical Care Medicine* 2005;33:990
3. Increased 1-hour survival (witnessed) (S-CPR vs. ACD+ITD)
   n=210 subjects; Wolcke et al., *Circulation* 2003;108:2201
4. Increased 24-hour survival (ACD +/- ITD)
   n=400 subjects; Plaisance et al., *Resuscitation* 2004;61:265

ResQCPR improved hemodynamics and short-term survival vs. controls

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The ResQTrial
A Pivotal Trial comparing S-CPR vs ACD+ITD

- Randomized, prospective, multicenter (7 US sites)
- NIH-funded
- Compliant with NIH and FDA regulations
- Oversight: DSMB and CEC
- Compared ACD+ITD versus S-CPR in 2470 subjects with out-of-hospital non-traumatic cardiac arrest

Aufderheide et al. Lancet 2011;377:301-311

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One Year Survival

	S-CPR	ResQCPR	Relative Increase
Cardiac etiology (n=1655)	6.0% (48/794)	9.0% (74/822)	49%
All patients (n=2470)	5.8% (68/1171)	7.8% (96/1233)	34%

First Medical Device approved by FDA to increase likelihood of survival after non-traumatic cardiac arrest

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Greg was our EP Fellow in 2007
He is currently practicing in Houston

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What can We do today to increase survival rates?

- Focus on quality CPR
  - Compression rate – use CPR feedback
  - Compression depth 2 inches – use CPR feedback
  - Full and rapid RECOIL – use CPR feedback or active decompression CPR
  - Correct ventilation rate/volume
- 30:2 for BLS
- ITD and ACD-CPR
- Automated CPR + ITD

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Potential Future Advances

Better FLOW
- Head up CPR to enhance brain flow
- Peri-shock care/ PEA with synchronized CPR
- Ongoing CPR to the cath lab and ECMO
- Post-resuscitation *active (a)* IPR improves brain flow

Better HEALING
- Reperfusion injury protection
- More rapid cooling for neuro-protection

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The Inspiration

A Problem in South Korea

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Head Up vs Head Flat CPR

Inherent Limitation of Flat CPR

Chest compressions increase arterial and venous pressures simultaneously, delivering a bidirectional high pressure compression wave to the brain with every compression.

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What is the optimal head position during CPR?

Hypothesis:

In cardiac arrest, elevation of the head with simultaneous use of CPR circulatory enhancement technologies (e.g. ITD) will reduce cerebral venous pressure, lower ICP, and improve outcomes.

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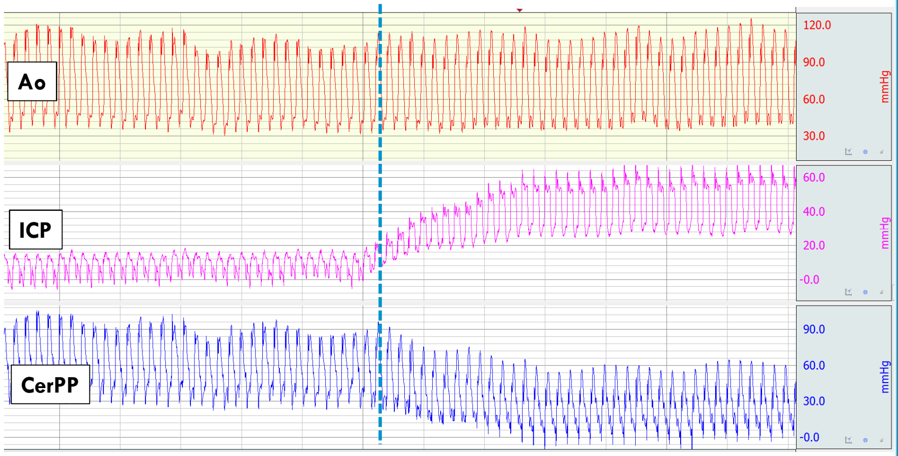
Supine 0° CPR +ITD　　30° Whole Body Tilt Head Down CPR +ITD



Change of position
(CPR rate 100/min)

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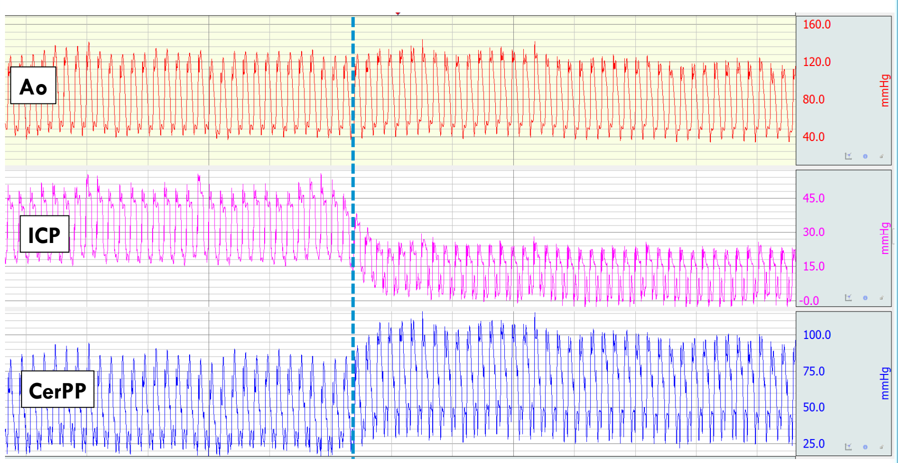
Supine 0° CPR　　30° Whole Body Tilt Head Up CPR + ITD



Change of position
(CPR rate 100/min)

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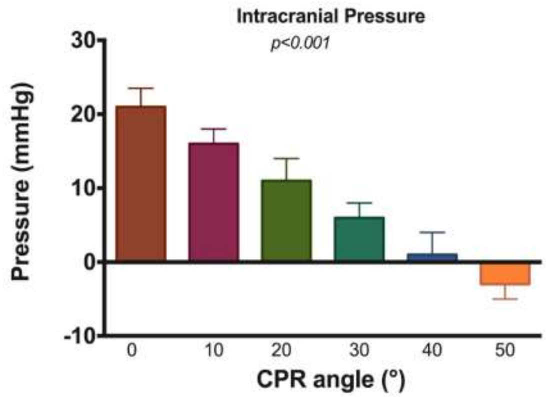
Head-Up CPR: Effect on Mean ICP



CPR angle relationship with mean Intracranial Pressure. p value is reported for linear trend.

ICP decreases with head elevation during CPR + ITD

Debaty et al. Resuscitation, 2015

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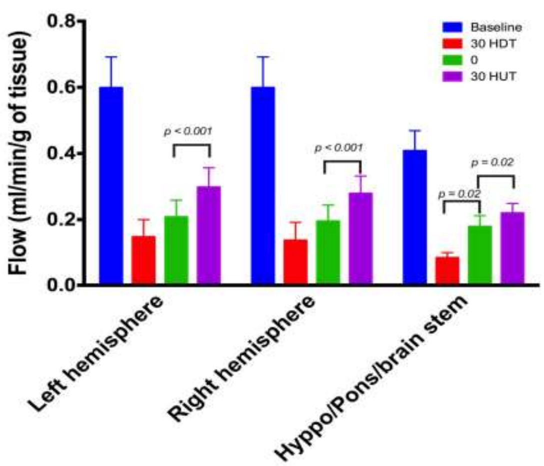
Brain Blood Flow Depends on Head Position



Brain blood flow is highest with head up CPR + ITD

Conclusions re: Head Up CPR

1. A potential breakthrough in understanding how to save the brain during CPR.
2. Head up CPR with the ITD enhances cerebral circulation by increasing blood flow to the brain and lowering resistance to blood flow within the brain.
3. Further research is needed.

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9/22/2016 Why Rialto Fire Department sees heart attack survival rates 3 times above national average

http://www.sbsun.com/health/20160920/whyrialtofiredepartmentseesheartattacksurvivalrates3timesabovenationalaverage&

San Bernardino County Sun (http://www.sbsun.com)

By Jim Steinberg, The Sun

Tuesday, September 20, 2016

RIALTO >> The Fire Department here has seen survival rates for sudden cardiac arrest that are three times the national average. The department credits its focused planning effort that has resulted in new procedures and the acquisition of specialized equipment.

"There is no single element of what we were trying to do here that is a silver bullet, but the combination of approaches is showing great results," said Fire Chief Mat Fratus.

The survival rate for Rialto is 32 percent with a five year goal of increasing to 50 percent or more, Fratus said.

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9/22/2016 Why Rialto Fire Department sees heart attack survival rates 3 times above national average

"Here are some of the elements in Rialto's success:

• Automated CPR resuscitation systems that allow department responders to provide other services while machine delivers CPR.

• Heads up CPR allowing improved blood circulation and oxygen delivery to the brain.

• Use of ResQPOD device, which serves as a regulator to restrict unnecessary airflow into the chest during CPR. This improves blood flow to the brain, fire officials say.

• Rapid response time and bystander CPR."

URL: http://www.sbsun.com/health/20160920/whyrialtofiredepartmentseesheartattacksurvivalrates3timesabovenationalaverage

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Better Perfusion to and in the Cath Lab and Beyond

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Recent Case

Message from Dr. Yannopoulos – January 31, 2016:

"Back after two vessel angioplasty!!!!

Great CPR Etco2 in the 40s
Ph 7.05
Let's hope he will do good

Great job Gents!!
He had no chance without the ECMO
100% death!
He was on ECMO for 45 min before he had ROSC after PCI"

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Minnesota Resuscitation Consortium's Advanced Perfusion and Reperfusion Cardiac Life Support Strategy for Out-of-Hospital Refractory Ventricular Fibrillation

Demetris Yannopoulos, MD; Jason A. Bartos, MD, PhD; Cindy Martin, MD; Ganesh Raveendran, MD, MPH; Emil Missov, MD, PhD; Marc Conterato, MD; R. J. Frascone, MD; Alexander Trembley, BS; Kevin Sipprell, MD; Ranjit John, MD, PhD; Stephen George, MD, PhD; Kathleen Carlson, MD; Melissa E. Brunsvold, MD; Santiago Garcia, MD; Tom P. Aufderheide, MD

Seventy-eight percent of patients survived to hospital admission and 55% (10 of 18) survived to hospital discharge, with 50% (9 of 18) achieving good neurological function (cerebral performance categories 1 and 2). No significant ECMO-related complications were encountered.

Conclusions—The MRC refractory VF/VT protocol is feasible and led to a high functionally favorable survival rate with few complications. (J Am Heart Assoc. 2016;5:e003732 doi: 10.1161/JAHA.116.003732)

Opportunity

For all patients between 18-75 years of age,
50% more could be alive
and functional with today's technologies!

Reperfusion Injury Protection

The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

MECHANISMS OF DISEASE

Myocardial Reperfusion Injury

Derek M. Yellon, D.Sc., and Derek J. Hausenloy, Ph.D.

CORONARY HEART DISEASE IS THE LEADING CAUSE OF DEATH WORLDWIDE, and 3.8 million men and 3.4 million women die of the disease each year. After an acute myocardial infarction, early and successful myocardial reperfusion with the use of thrombolytic therapy or primary percutaneous coronary intervention (PCI) is the most effective strategy for reducing the size of a myocardial infarct and improving the clinical outcome. The process of restoring blood flow to the ischemic myocardium, however, can induce injury. This phenomenon, termed myocardial reperfusion injury, can paradoxically reduce the beneficial effects of myocardial reperfusion.

From the Hatter Cardiovascular Institute, University College London Hospital and Medical School, London. Address reprint requests to Dr. Yellon at the Hatter Cardiovascular Institute, University College London Hospital and Medical School, 67 Chenies Mews, London WC1E 6HX, United Kingdom, or at hatter-institute@ucl.ac.uk.

N Engl J Med 2007;357:1121-35.

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Systematic Approach to Survival after Cardiac Arrest
A Bundled-Approach to Organ Preservation

	Optimize Perfusion	Minimize Cellular Permeability	Restore Blood Brain Barrier	Optimize Intra-cellular Metabolism and Biochemistry	Minimize Post-Resuscitation Injury Cascades
CPR Devices and Head Position	X				X
Synthetic surfactants		X	X		X
Anesthetics, Inert gases, Cyclosporin A, Valproic Acid, other		X		X	X
Hypothermia		X	?	X	X
Revascularization	X				X

Lurie et al 2015 Anesthesia and Analgesia

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After 50 + years

- We have made some progress.
- We are still at the beginning.
- The unexpected detours are as important as the planned route.
- With our better understanding of CPR and new devices we must save more lives.

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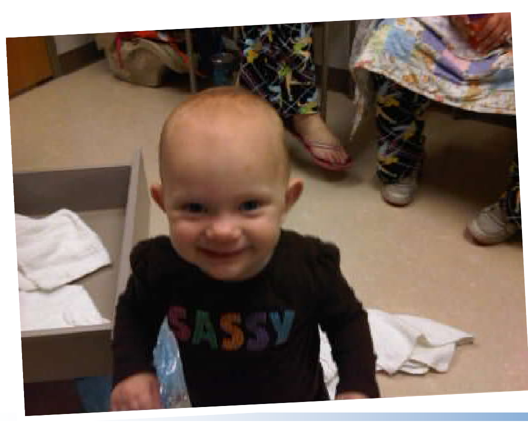
>30% Survival with Good Brain Function



Little Serenity Joy:
15 months old and status post in utero
Take Heart America CPR

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Take Heart America Save

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Best Practice

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Celebrate your saves
Track your outcomes

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Thank You!

For correspondence:
keithlurie@icloud.com

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