CPR

The Science Behind the Hands

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MEDIC ONE FOUNDATION

KING MEDIC ONE COUNTY

KING TRAINING COUNTY

HARBORVIEW MEDICAL CENTER UW Medicine

Life Sciences DISCOVERY FUND

CPR-The Science Behind the Hands

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Senior Consultant, Clinician Scientist

& Director of Research

Department of Emergency Medicine

Singapore General Hospital

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Senior Consultant, Ministry of Health

Director, Unit for Prehospital Emergency Care

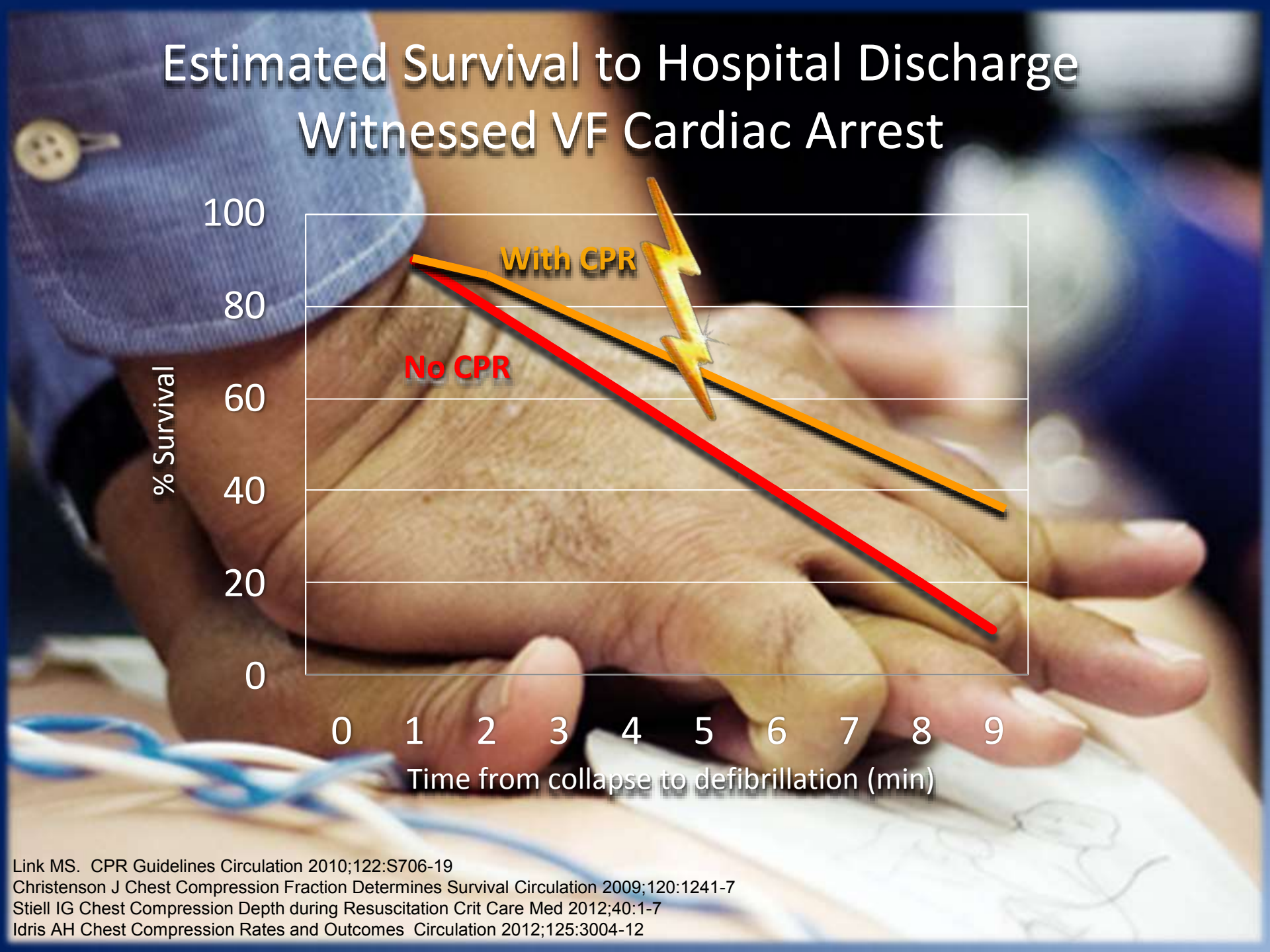
What Saves Lives in Resuscitation?

Therapeutic hypothermia
Transcutaneous pacing
Sodium bicarbonate Rx
Calcium, Magnesium
Fluids and Pressors
Antiarrhythmic Rx
Epi/Vasopressin
O_2/intubation
Shock
CPR

CPR

The Cornerstone of Resuscitation

Estimated Survival to Hospital Discharge Witnessed VF Cardiac Arrest



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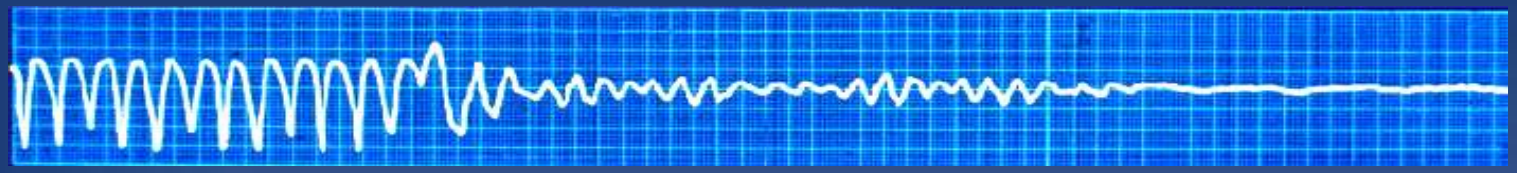
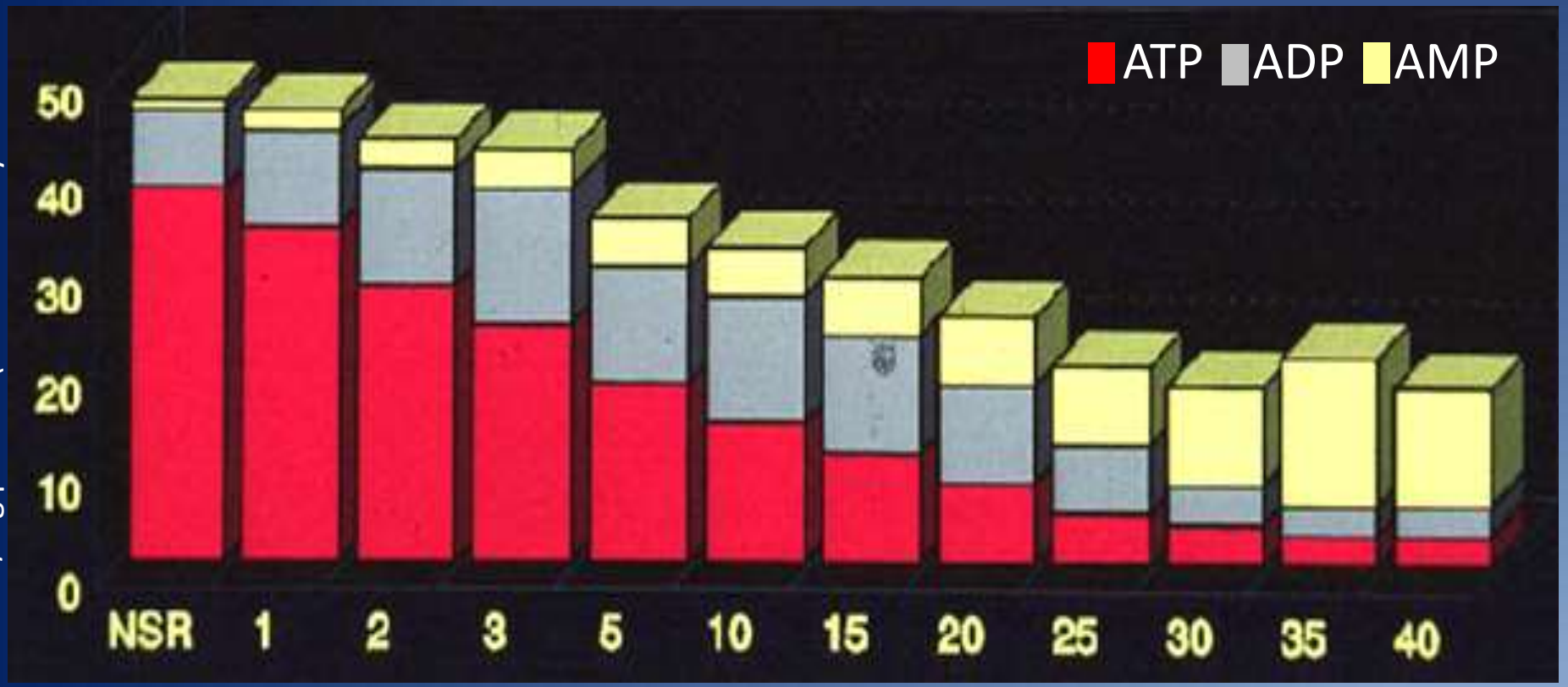
Adenosine Nucleotide Concentrations During VF

n = 10 swine (~10 samples/time period)

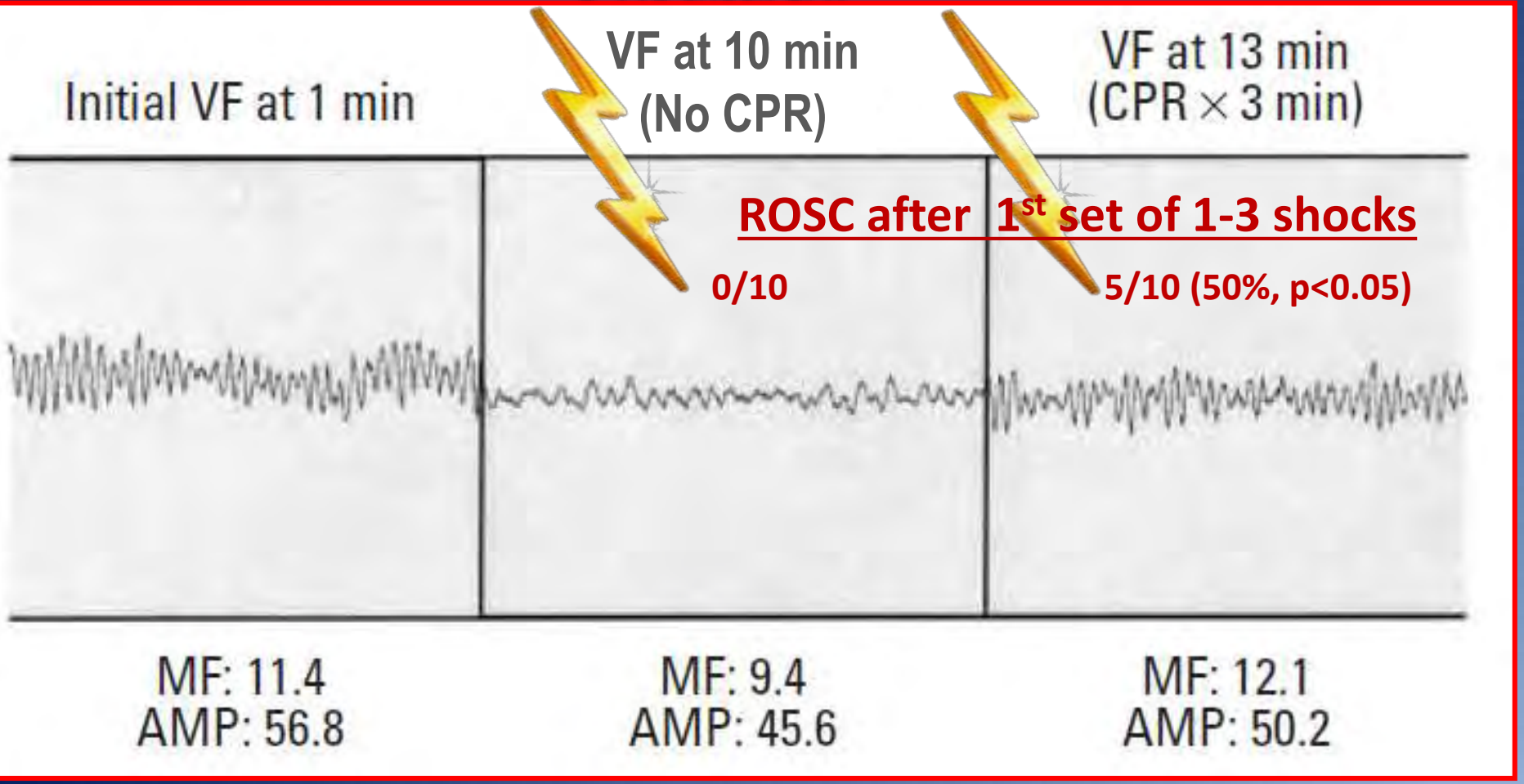




Neumar RW. Ann Emerg Med 1991;20:222-9

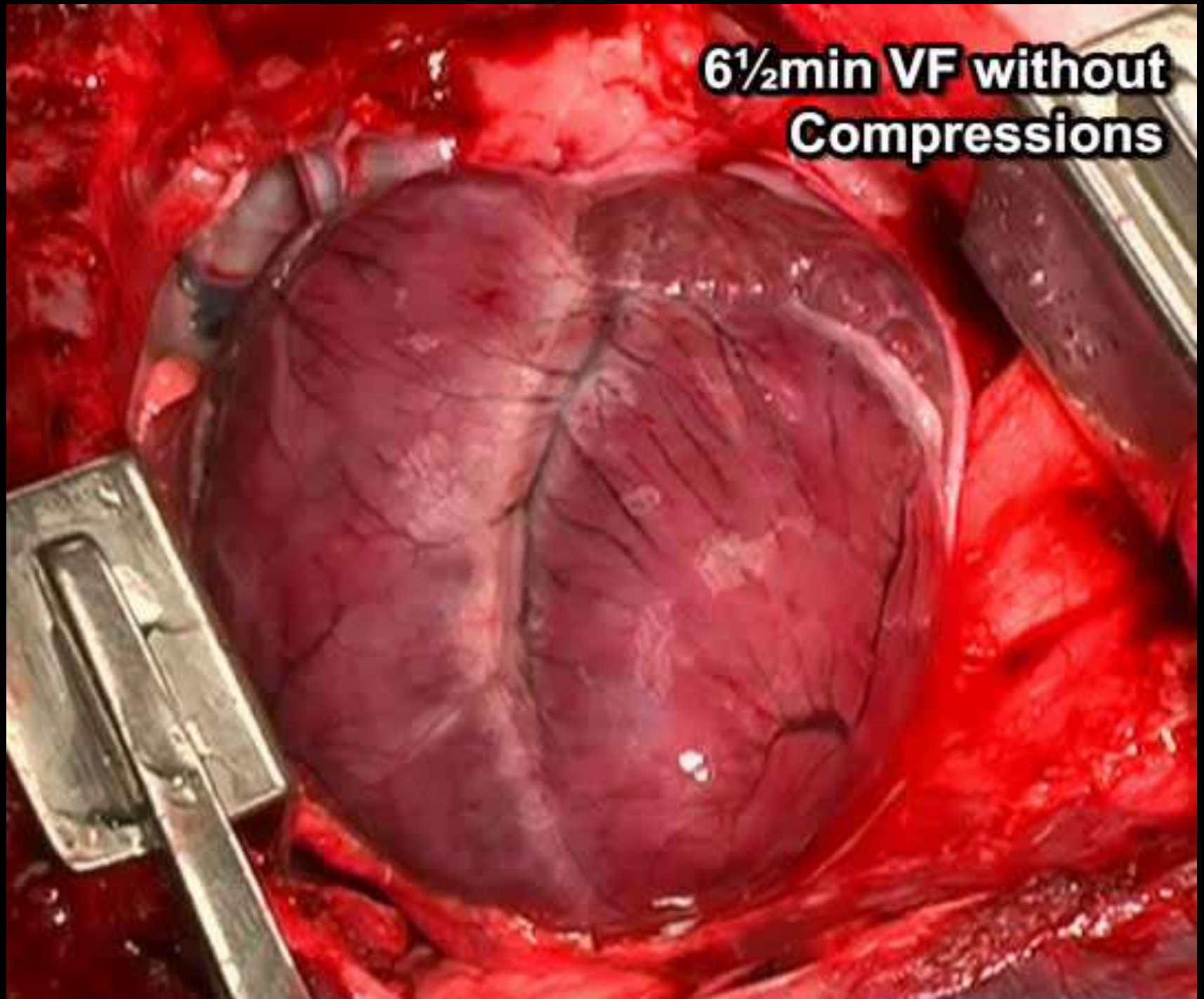
CPR Makes It Easier to Defibrillate Successfully

n= 32 swine → UnTx VF x 10' → R → No Pre-shock CPR / 3' Pre-shock CPR



MF = VF median frequency in Hz; AMP = VF amplitude in mV

Berg RA. Ann Emerg Med 2002;40:563-70

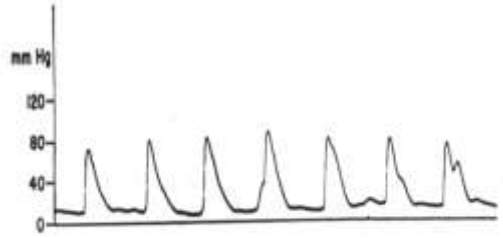

6½min VF without
Compressions


6½min VF + 3½min
Compressions

J.A.M.A., July 9, 1960

CLOSED-CHEST CARDIAC MASSAGE

W. B. Kouwenhoven, Dr. Ing., James R. Jude, M.D.
and
G. Guy Knickerbocker, M.S.E., Baltimore



Blood pressure produced in an adult by closed-chest cardiac massage.

Cardiac resuscitation after cardiac arrest or ventricular fibrillation has been limited by the need for open thoracotomy and direct cardiac massage. As a result of exhaustive animal experimentation a method of external transthoracic cardiac massage has been developed. Immediate resuscitative measures can now be initiated to give not only mouth-to-nose artificial respiration but also adequate cardiac massage without thoracotomy. The use of this technique on 20 patients has given an over-all permanent survival rate of 70%. Anyone, anywhere, can now initiate cardiac resuscitative procedures. All that is needed are two hands.

Kouwenhoven WB. JAMA 1960;173:1064-7

Thoracic Pump Mechanism of CPR

Pressure-synchronized Cineangiography During Experimental Cardiopulmonary Resuscitation

James T. Niemann, M.D., John P. Rosborough, Ph.D., Mark Hausknecht, M.D., Daniel Garner, M.S., and J. Michael Criley, M.D.

Visualization of Cardiac Valve Motion in Man During External Chest Compression Using Two-dimensional Echocardiography

Implications Regarding the Mechanism of Blood Flow

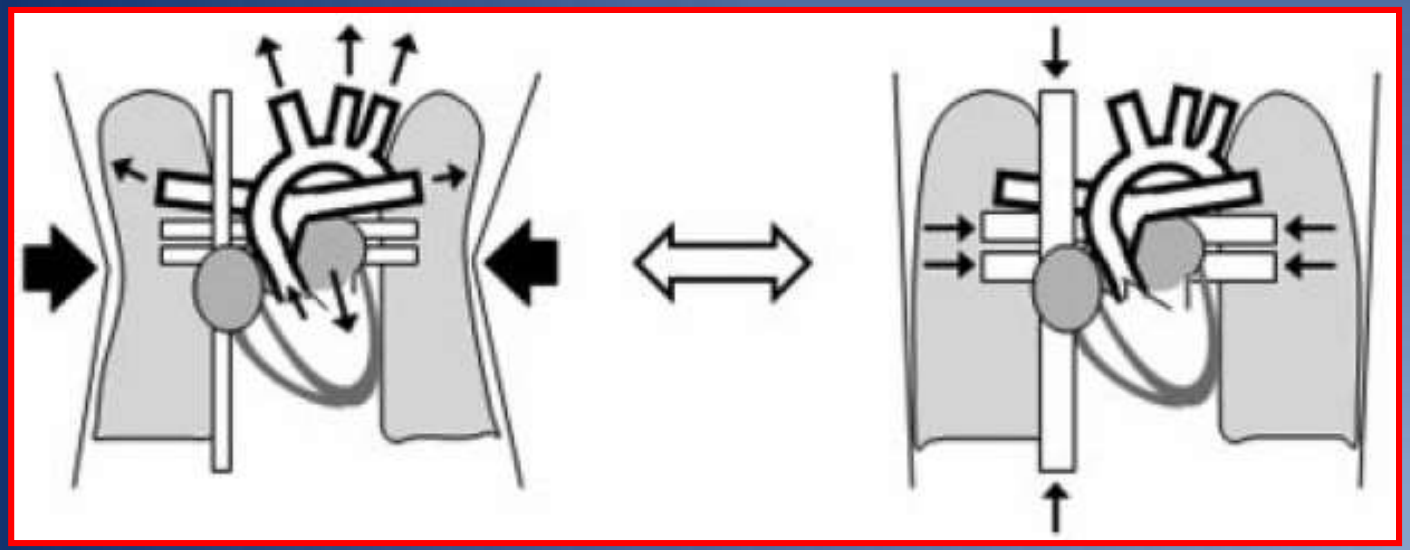
Jeffrey A. Werner, M.D., H. Leon Greene, M.D., Carolyn L. Janko and Leonard A. Cobb, M.D.

Two-dimensional echocardiography during CPR in man: implications regarding the mechanism of blood flow

JEFFREY A. WERNER, MD, FACC; H. LEON GREENE, MD, FACC; C. L. JANKO; LEONARD A. COBB, MD, FACC

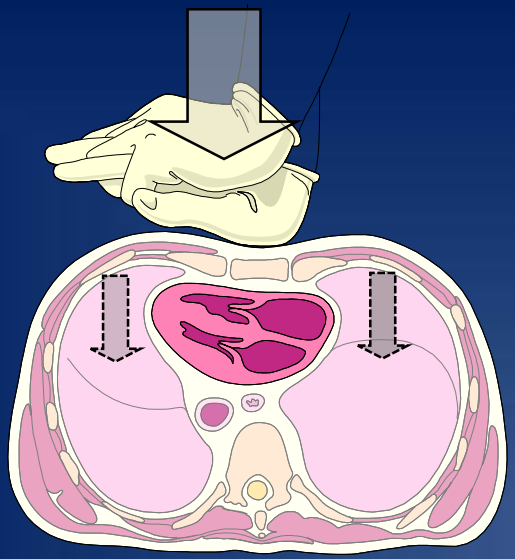
Mechanisms of Blood Flow During Cardiopulmonary Resuscitation

Michael T. Rudikoff, M.D., W. Lowell Maughan, M.D., Mark Effron, M.D., Paul Freund, and Myron L. Weisfeldt, M.D.



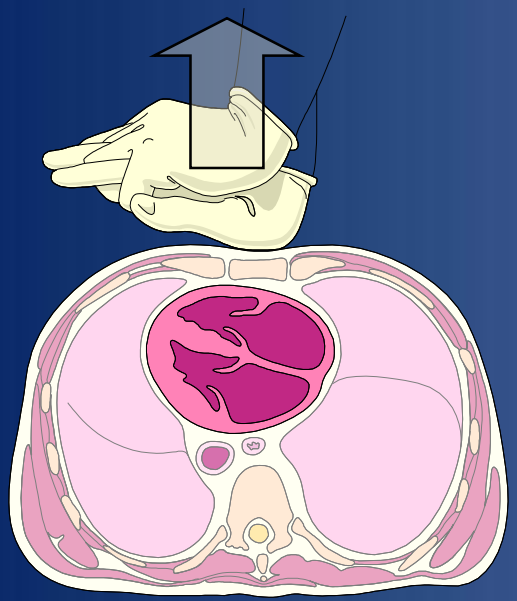
Compression **Relaxation**

Niemann JT Circulation 1981;64:985-91 Werner JA. Circulation 1981;64:1417-21; Crit Care Med 1981;9:375-6 Rudikoff MT, Circulation 1980;61:345-52



Compression

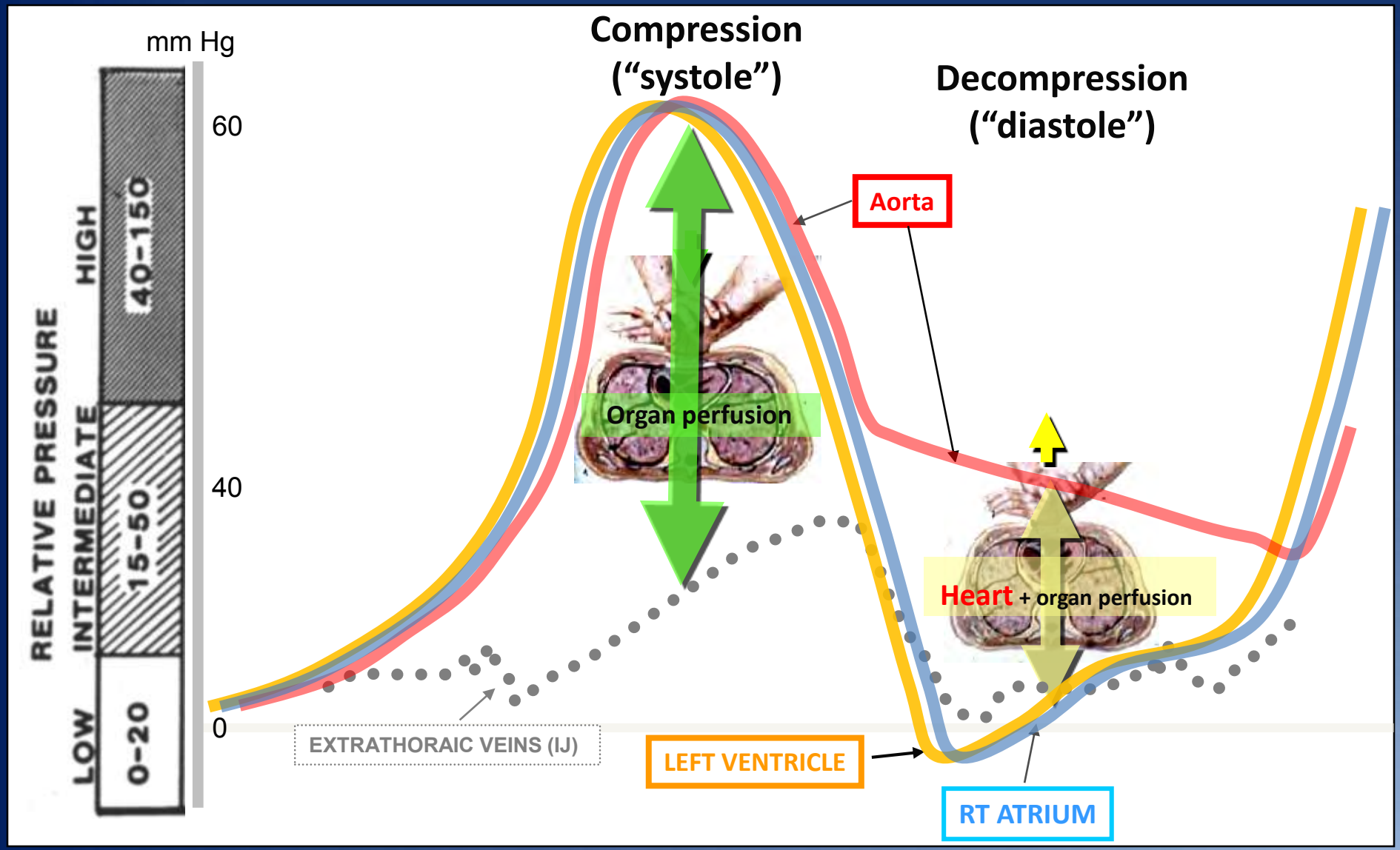
- Increased intrathoracic pressure
- Ejects blood from heart and lungs
- "Good" compression increases forward output and BP



Decompression (recoil)

- Decreased intrathoracic pressure
- Refilling of heart and lungs
- "Good" recoil → ↑vacuum → ↑refilling → ↑forward output

Why recoil is Important



Criley JM et al. Circulation 1986;74(IV):42-50 (modified).

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

CPR Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital : A Consensus Statement From the American Heart Association

Peter A. Meaney, Bentley J. Bobrow, Mary E. Mancini, Jim Christenson, Allan R. de Caen, Farhan Bhanji, Benjamin S. Abella, Monica E. Kleinman, Dana P. Edelson, Robert A. Berg, Tom P. Aufderheide, Venu Menon and Marion Leary

4 Metrics of High Performance CPR

- Optimize chest compression rate: 100-120 cpm
- Maximize compression depth: ≥ 50 mm (2”)
- Minimize interruptions: chest compression fraction >80%
- Promote full chest recoil: no leaning

Meaney PA. Circulation 2013;128:417-35

Relationship Between Chest Compression Rates and Outcomes From Cardiac Arrest

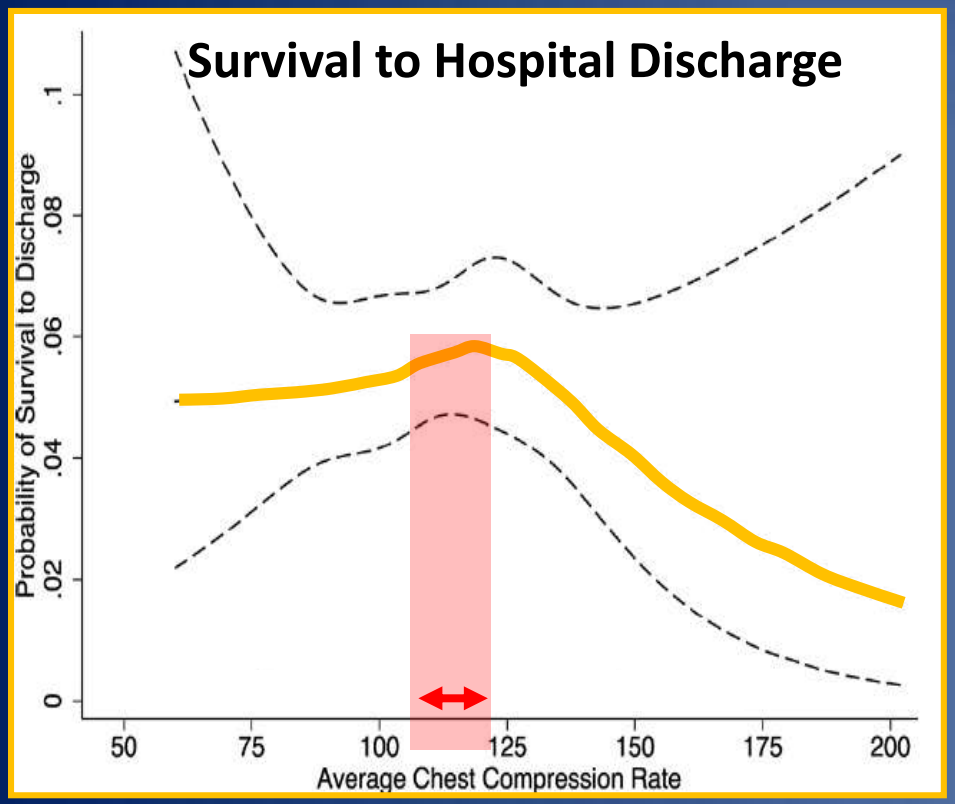
Ahamed H. Idris, MD; Danielle Guffey, BS; Tom P. Aufderheide, MD; Siobhan Brown, PhD; Laurie J. Morrison, MD, MSc; Patrick Nichols, DO; Judy Powell, BSN; Mohamud Daya, MD; Blair L. Bigham, MSc; Dianne L. Atkins, MD; Robert Berg, MD; Dan Davis, MD; Ian Stiell, MD, MSc; George Sopko, MD, MPH; Graham Nichol, MD, MPH; the Resuscitation Outcomes Consortium (ROC) Investigators

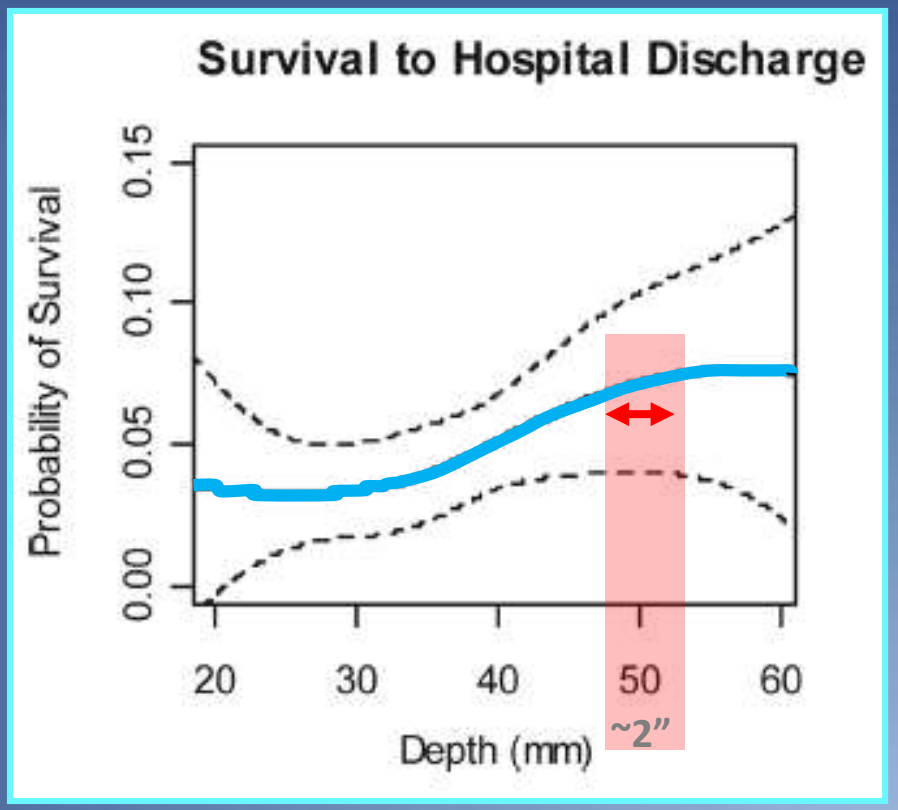
- 3098 adults out-of-hospital cardiac arrest
- ≥5 min electronic chest compression rate recordings

- 1029 adults out-of-hospital cardiac arrest
- ≥5 min electronic chest compression depth recordings

What is the role of chest compression depth during out-of-hospital cardiac arrest resuscitation?

Ian G. Stiell, MD; Siobhan P. Brown; James Christenson; Sheldon Cheskes; Graham Nichol; Judy Powell; Blair Bigham; Laurie J. Morrison; Jonathan Larsen; Erik Hess; Christian Vaillancourt; Daniel P. Davis; Clifton W. Callaway; the Resuscitation Outcomes Consortium (ROC) Investigators





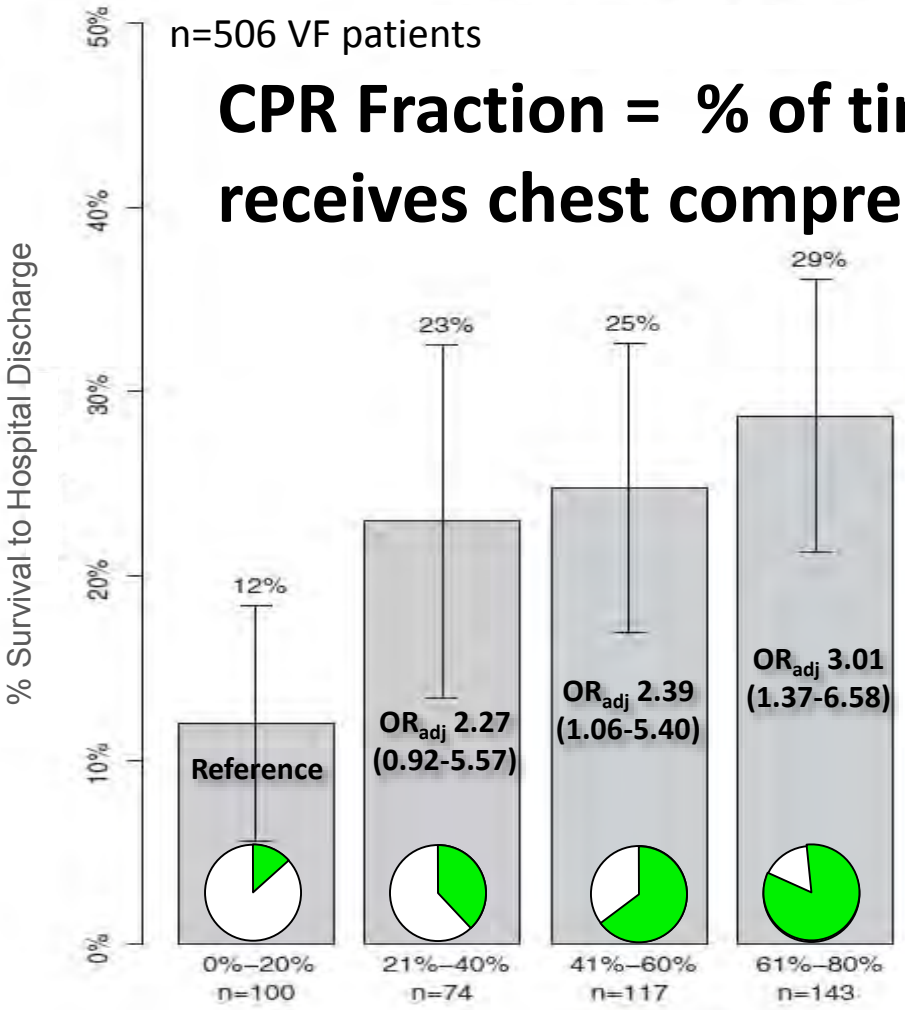
Idris AH. Circulation 2012;125:3004-12

Stiell IG. Crit Care Med 2012;DOI:10.1097/CCM.0b013e31823bc8bb

Pauses are BAD!
Effect of CPR Fraction on Survival in VF Arrest

n=506 VF patients

CPR Fraction = % of time a pulseless patient receives chest compressions (goal >80%)



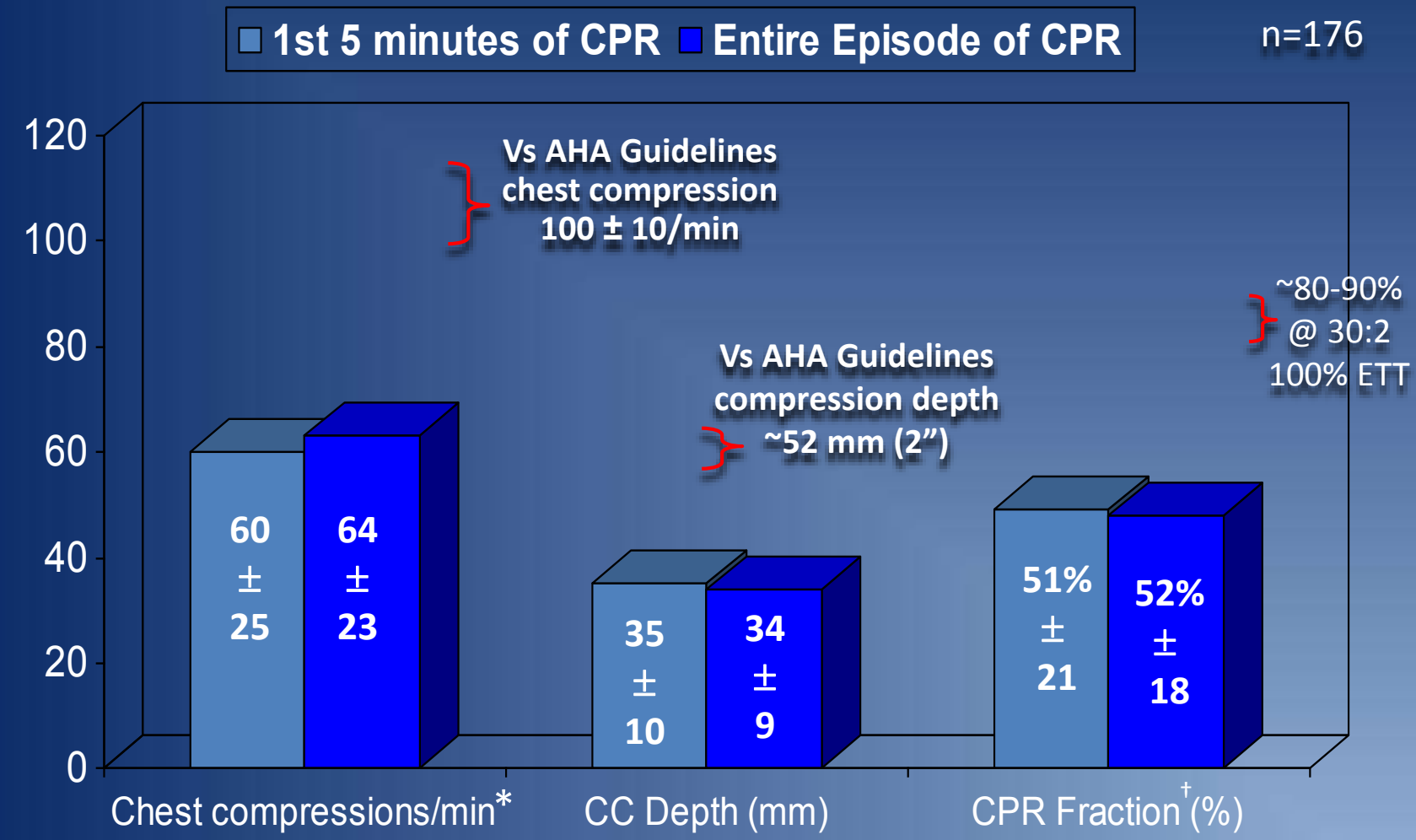
↑10% ΔCPR fraction → ↑OR$_{adj\ survival}$ 1.11 (1.01,1.21)

(OR$_{adj}$: age, sex, arrest location, bystander witnessed, bystander CPR, EMS response time, EMS site, chest compression rate, chest compression fraction category)

Christenson J. Circulation 2009;120:1241-7

*Interruption= any pause > 2-3 sec

Actual Quality of CPR During Out-of-Hospital Cardiac Arrest

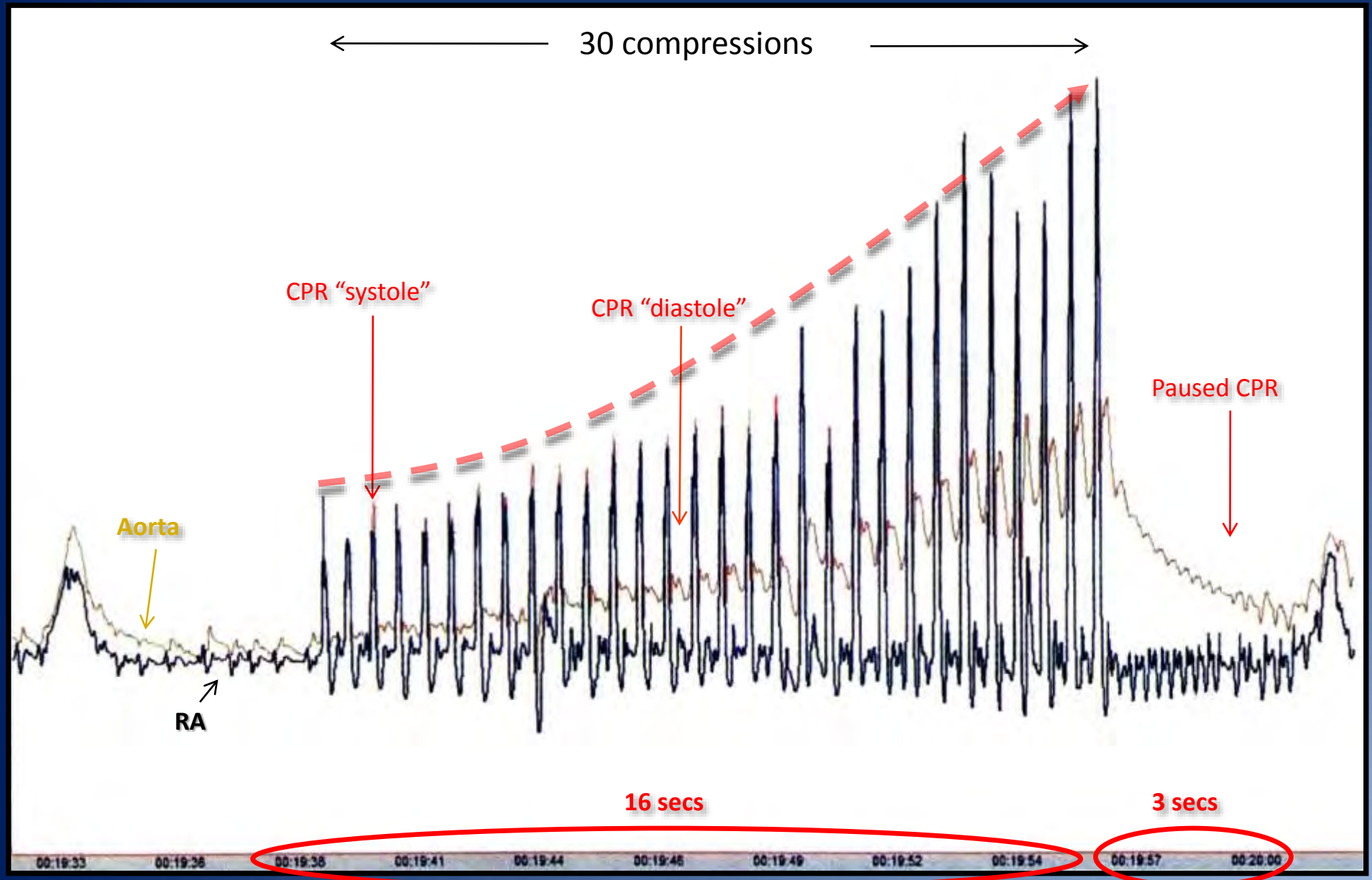


*Average # compressions given per minute vs instantaneous rate at which compressions, when given, were administered (120 ± 20)

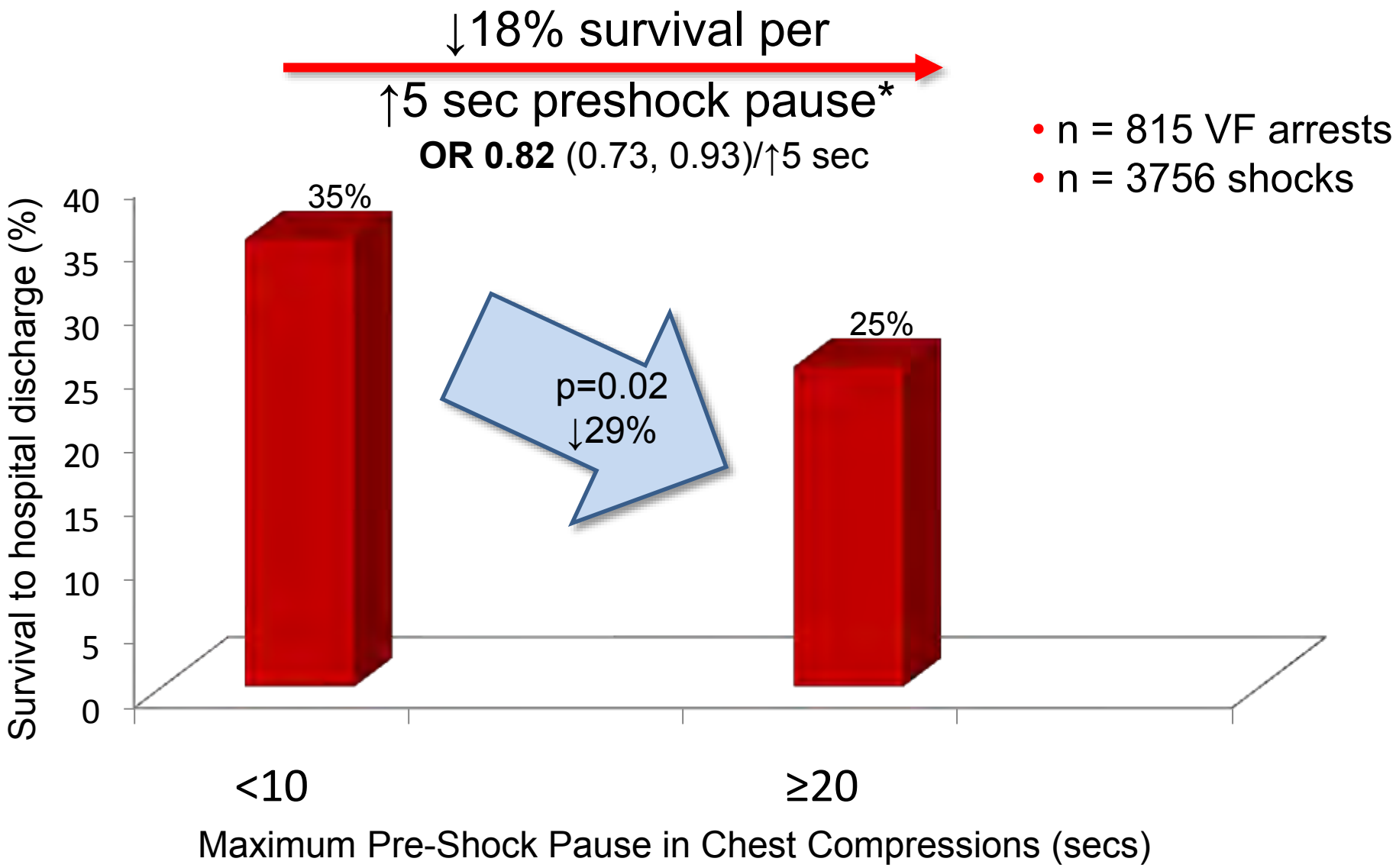
† % time with active chest compressions in absence of spontaneous circulation

Wik L et al JAMA 2005;293:299-304

The Price of CPR Pauses

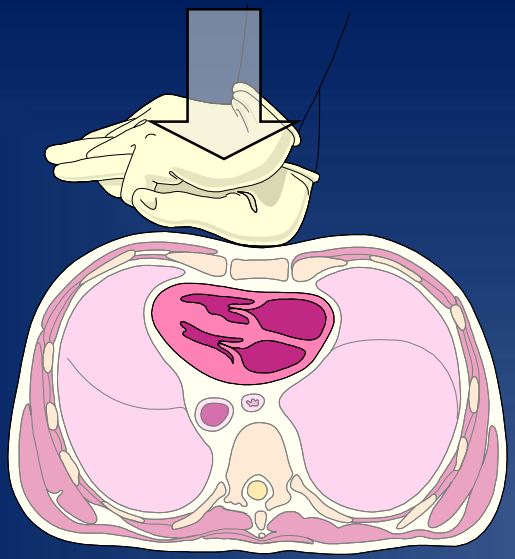


Pre-Shock Pauses and Cardiac Arrest Survival



Cheskes S et al. Circulation 2011;124:58-66

*Adjusted multivariable logistic regression model for age, sex, public location, witness status, bystander CPR, and time from 9–1-1 dispatch to first vehicle arrival



Compression

- Increased intrathoracic pressure
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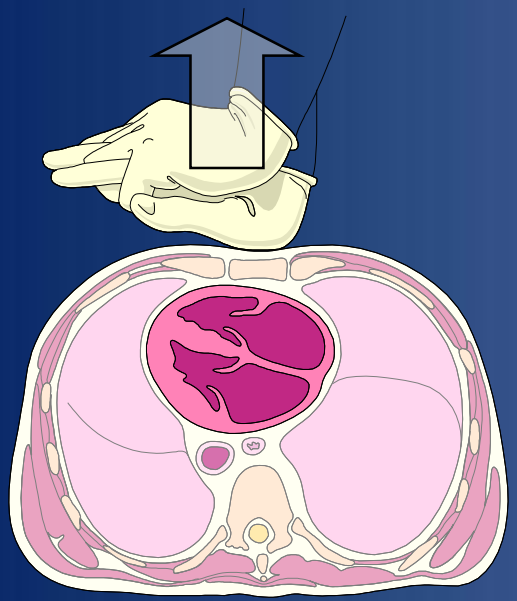
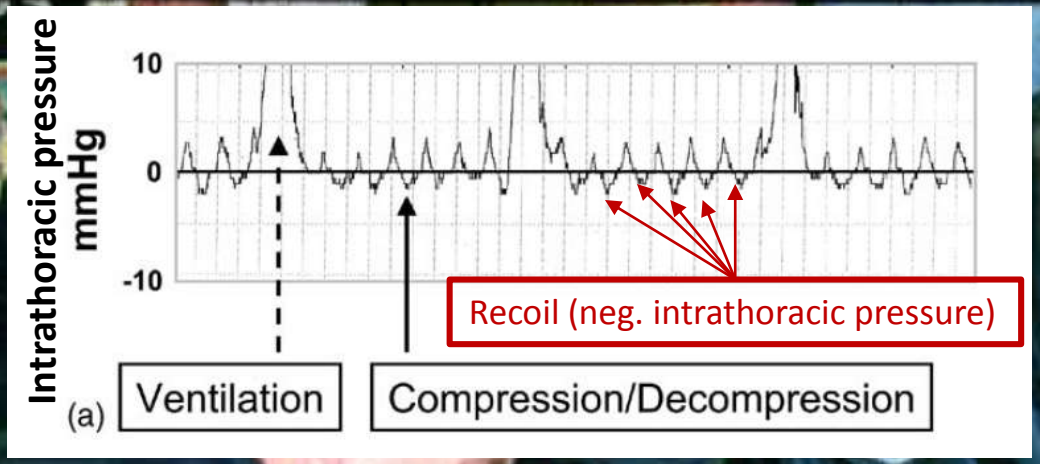
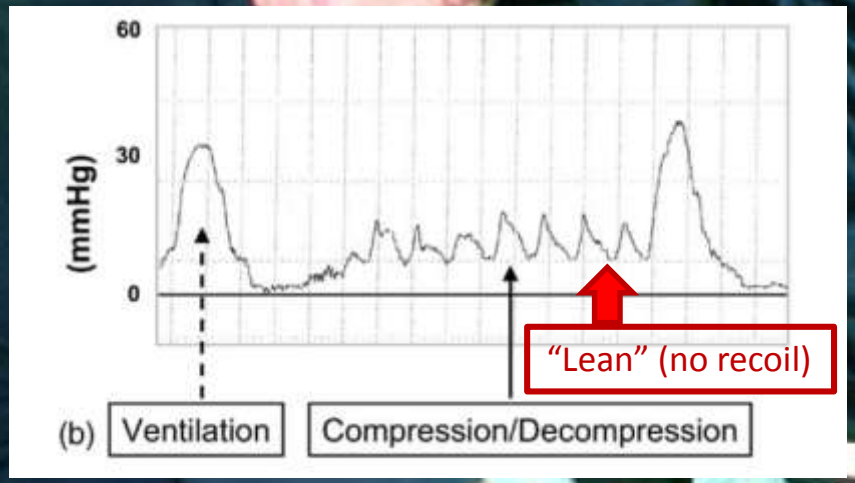
- "Good" compression increases forward output and BP
- Organ perfusion



Decompression (recoil)

- Decreased intrathoracic pressure
- Refilling of heart and lungs
- "Good" recoil → ↑vacuum → ↑refilling → ↑forward output
- Coronary perfusion





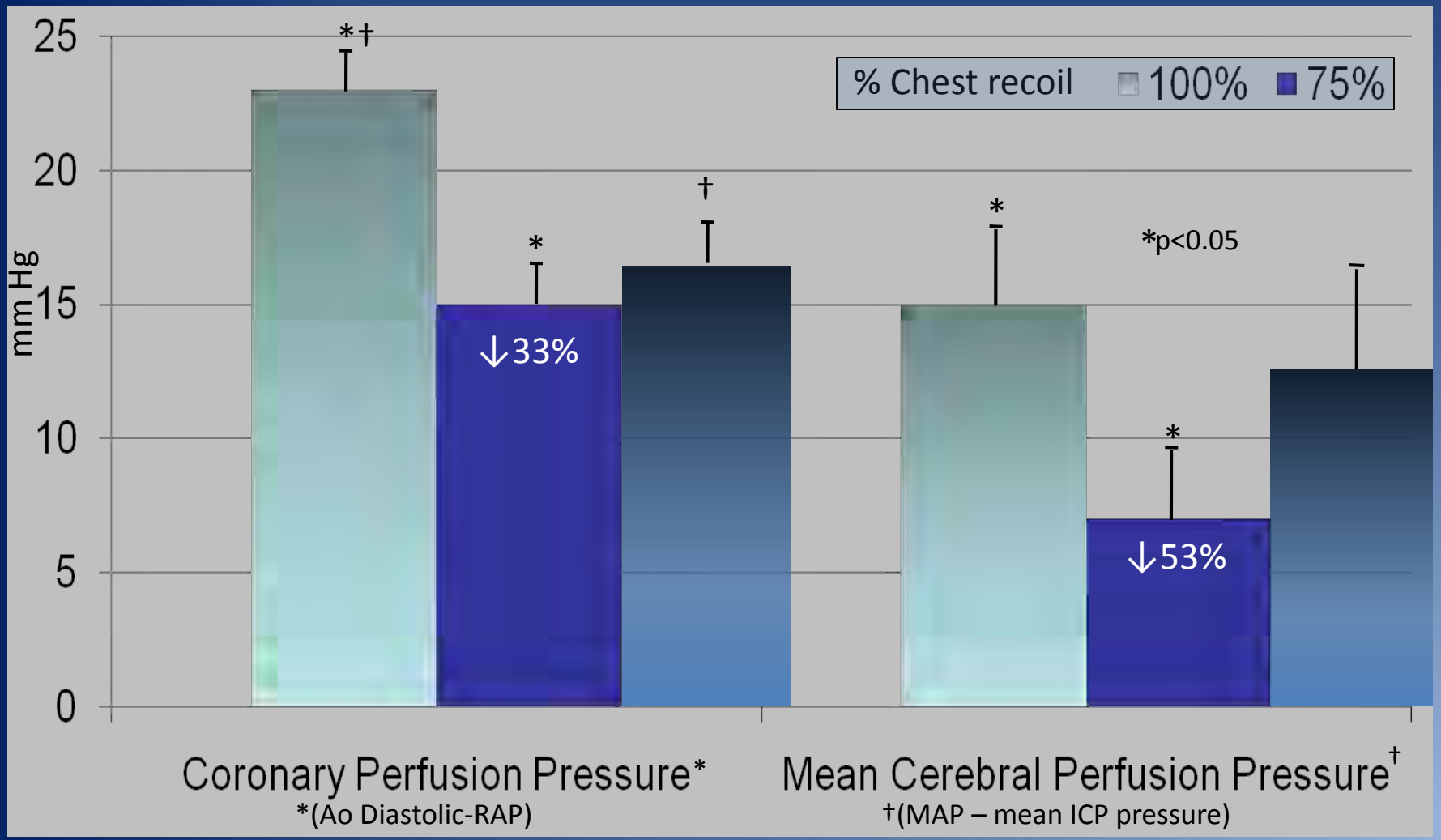
- n= 108 cardiac arrests
- 112,569 chest compressions (CC)
- CPR-sensing defibrillator
- "Leaning" = ~ 5 lbs residual force
  - Seen in 91% resuscitations
  - Affected >20% of CC in ~20% pts

Aufderheide TP. Resuscitation 2005;64:353-62

Fried DA. Resuscitation 2011;82:1019-24

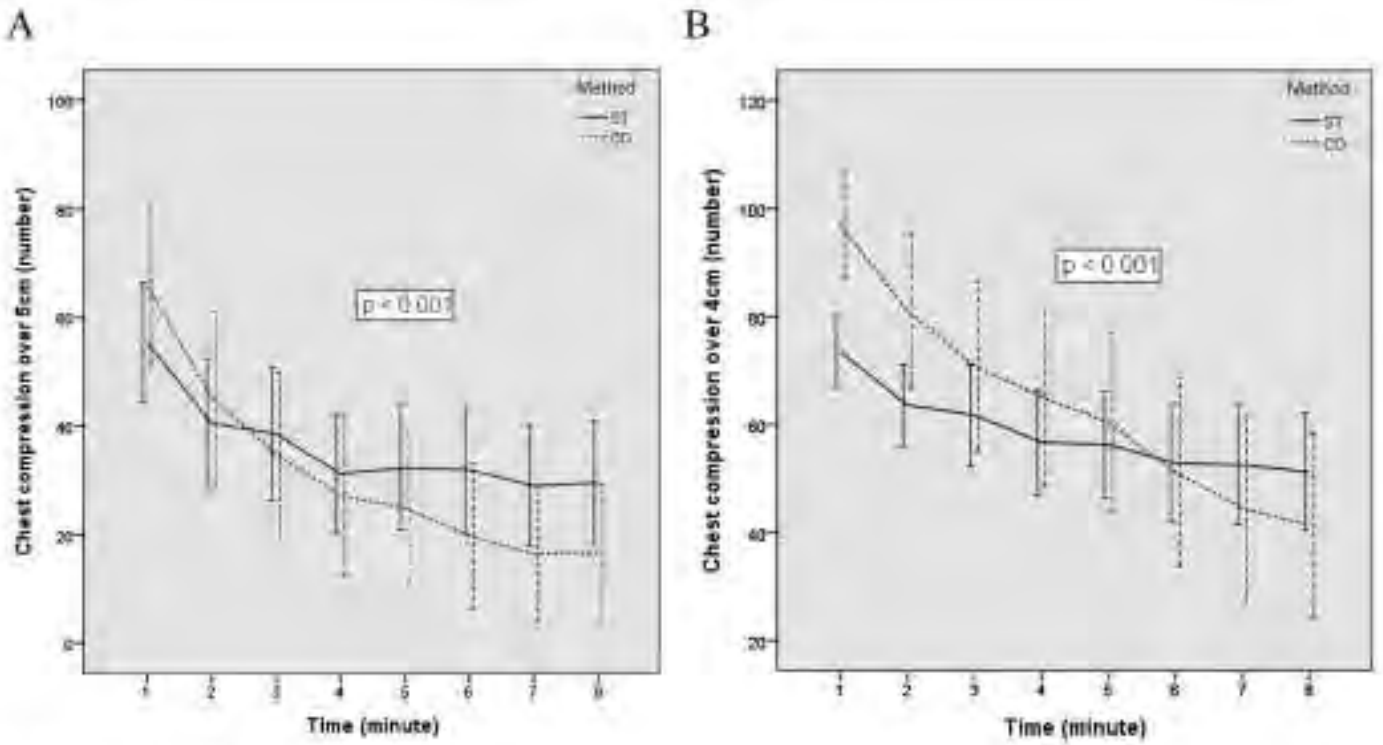
Effect of Incomplete Chest Decompression On Coronary and Cerebral Perfusion Pressures

n=9 instrumented swine → std CPR (100% recoil) x 3' → CPR (75% recoil) x 1' → std CPR (100% recoil)



Yannopoulos D et al. Resuscitation 2005;64:363-72; Paradis et al JAMA 1990;263:3257-8

CPR Quality starts to decline within 2 mins



ST: Standard group.
CO: Compression-only group.

Figure 3 The change in number of adequate chest compressions with each CPR method. A. Chest compression depth more than 5 cm. **B**. Chest compression depth more than 4cm.

Comparison of CPR quality and rescuer fatigue_Shin et al SJTREM 2014

Is this Overkill?

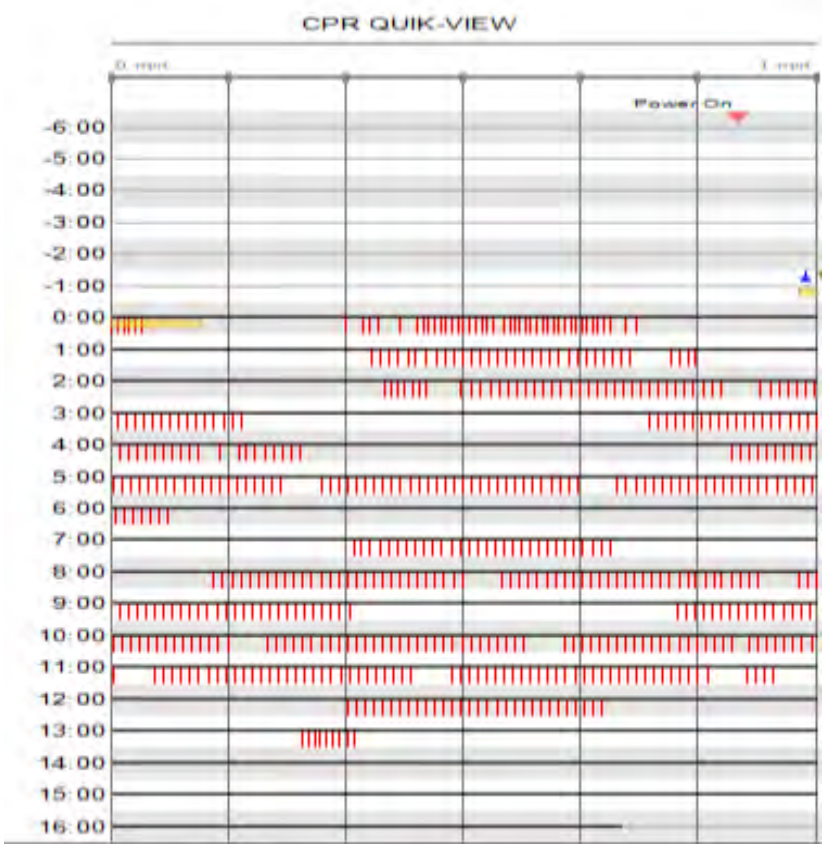
Cardiac arrest?

Fire bikes TO THE rescue

They attend to 58 such cases after being fitted with defibrillators

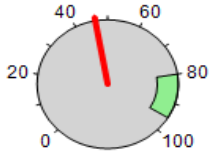
Quality CPR?

What about Mechanical CPR?



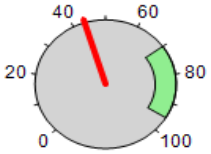
Interruptions to CPR during device deployment

CPR Ratio (/total time)



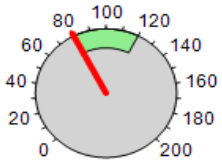
7:44 / 16:44 = 46 %

Compressions Ratio (/total time)



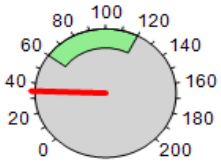
7:17 / 16:44 = 44 %

Compression Rate



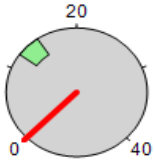
80/minute

Compressions/minute

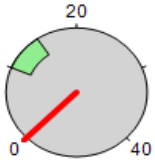


35/minute

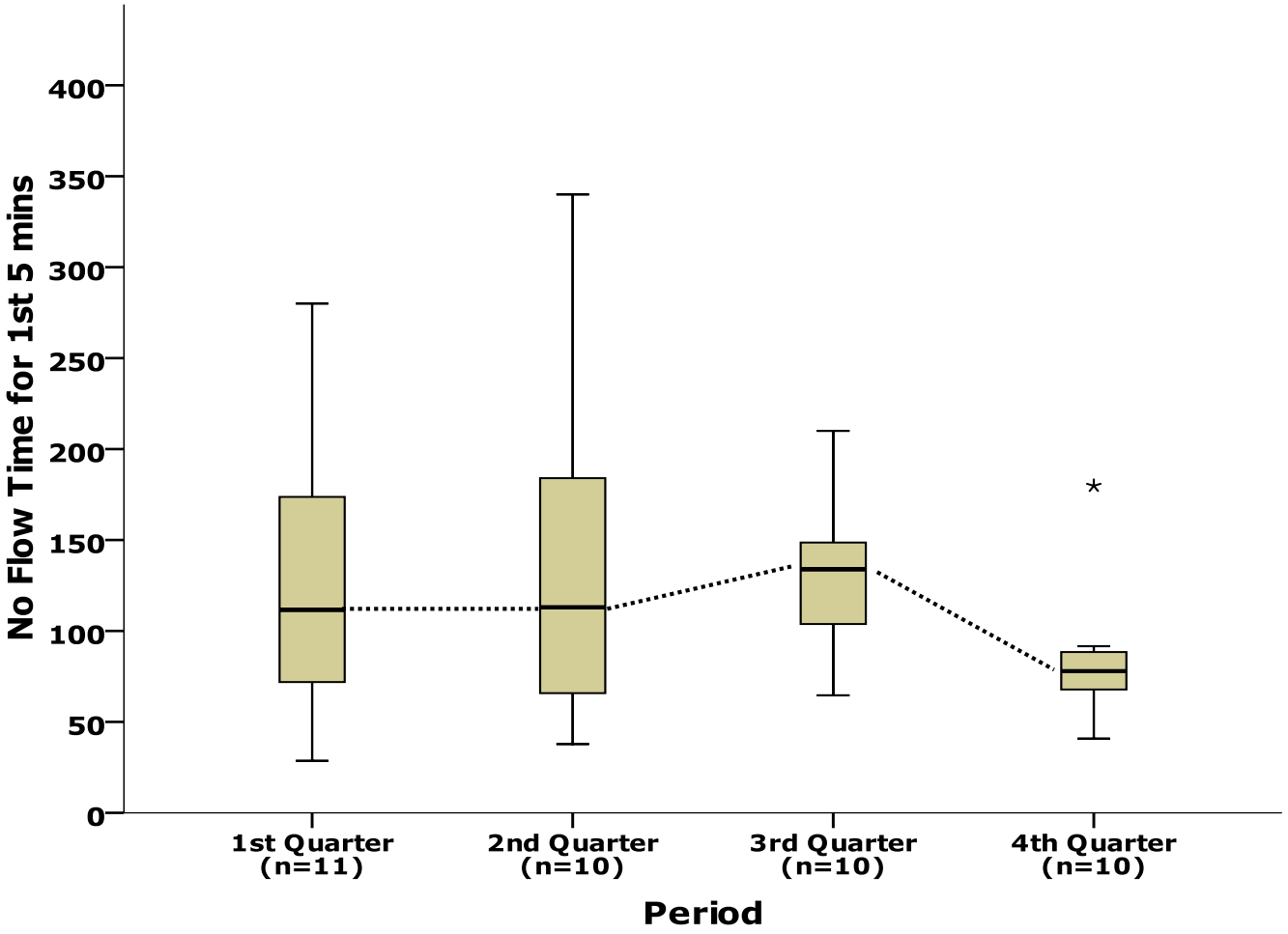
Ventilation Rate



Ventilations/minute



No Flow Time for 1st 5 mins of resuscitation (Mechanical CPR)



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