Monitoring CPR

"Performing CPR without measuring the effects is like flying an airplane without an altimeter"

Max Harry Weil

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

Cardiopulmonary Resuscitation 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

November 2013

"High quality CPR is primary component influencing survival"

"Monitor CPR"

Barrier to High Quality Pediatric CPR

Survey of professionals

"Use of own sense of adequate depth rather than objective quantitave measurements".....>70% of providers

De Maio, NAEMSPE abstract

Introduction

- Recognition of cardiac arrest
  - Gasping
  - Pulse check
- BP and CVP (CoPP)
- ETCO2
- Artifacts/problems

Gasping ventilation

- 55% of 445 prehospital arrests

  Clark *AEM* 1992

- 40% of 100 prehospital arrests

  Bang *Resus* 2003

- 39% of 113 prehospital arrests
  - Survival **39%** vs **9%** (aOR 5.1; 95%CI 2.7-9.4)

  Bobrow *Circ* 2008

Gasping ventilation

Brainstem activity

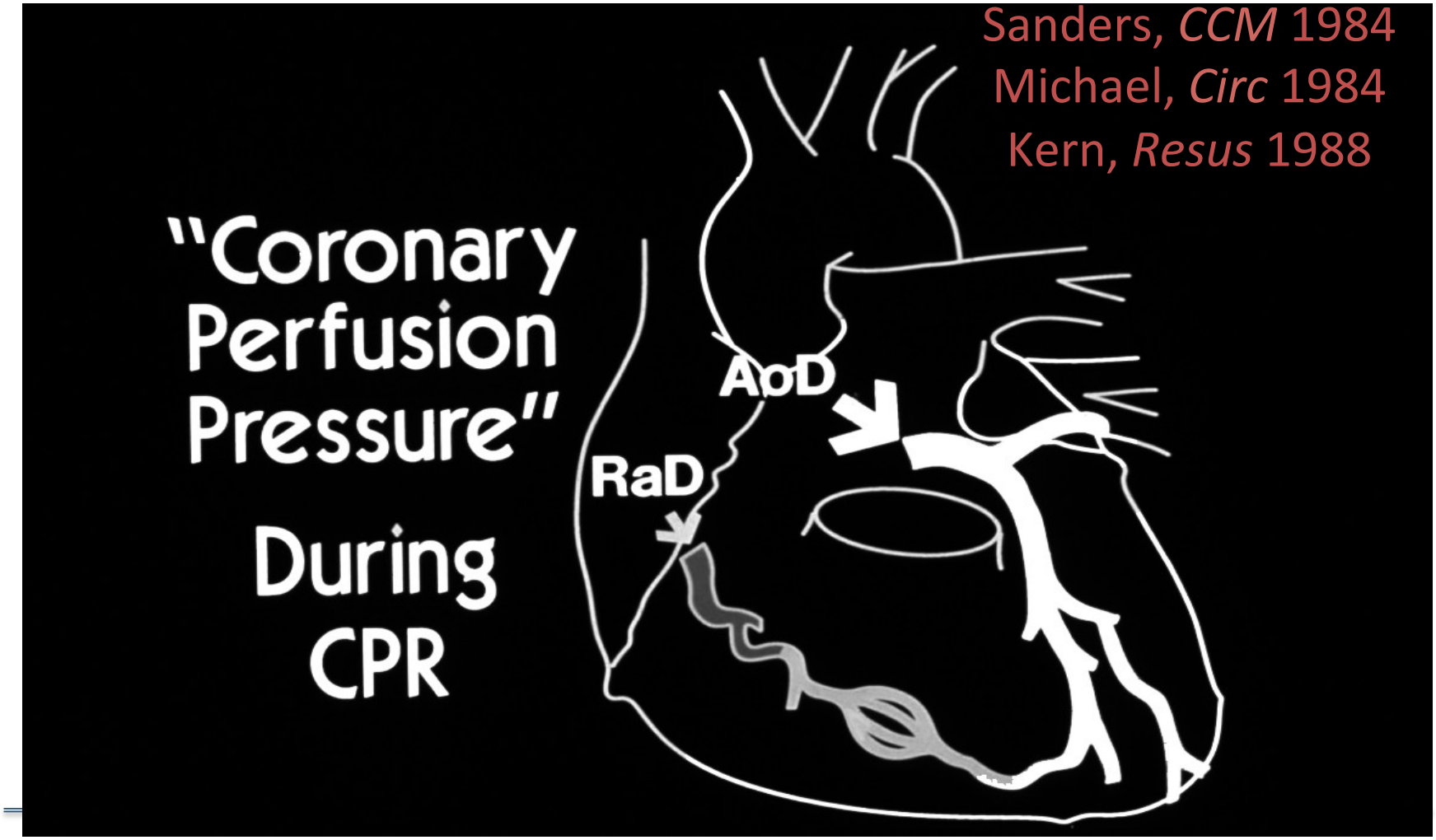
- Brainstem still has some activity
  - Group most likely to respond to CPR
- Brainstem activity returns from GOOD CPR
  - Adequate cerebral perfusion
- Bystanders, telephone dispatchers, professionals often misinterpret gasping as "not cardiac arrest"
- Enhances blood flow (no need for assisted ventilation)

CPR Quality

- **Physiologic Parameters**
  - Intra-arterial pressure
    - If relaxation phase (diastolic) pressure <20 mm Hg attempt to improve CPR quality

What is the evidence for this change?

Coronary Perfusion Pressure Critically Important for Successful CPR



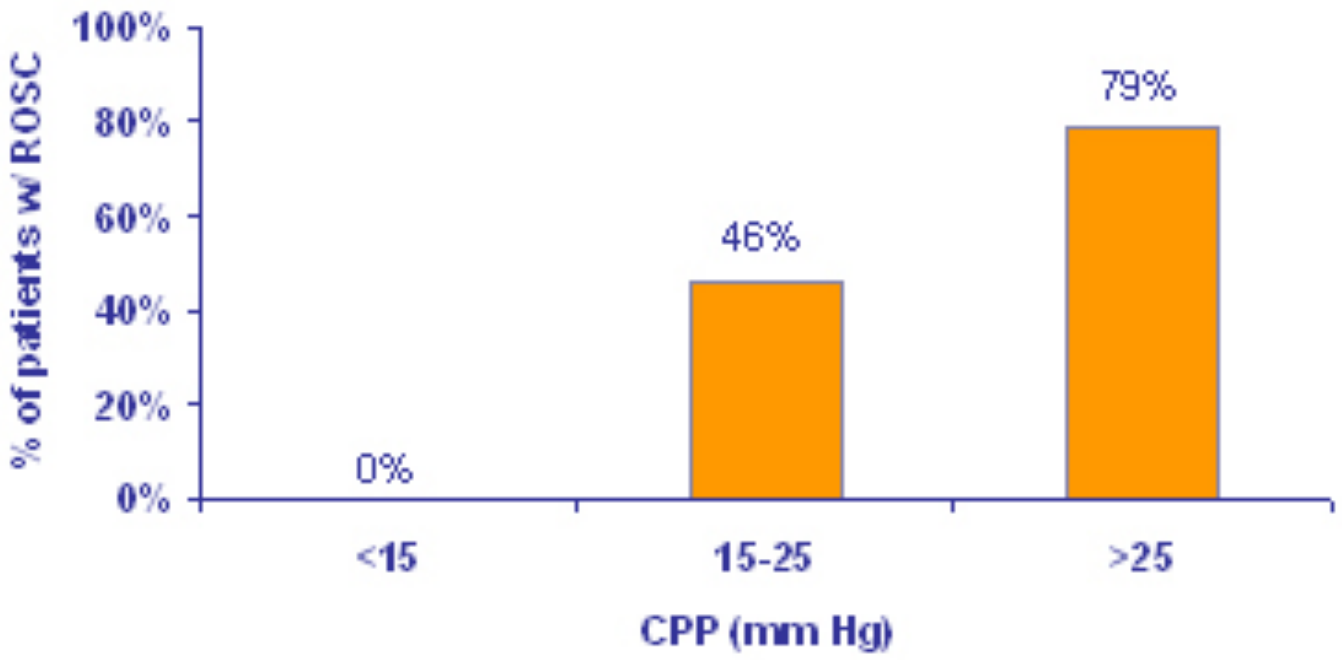
AoD >30 mmHg; CPP >20 mmHg

Coronary Perfusion Pressure Predictor of 24-hour Survival

When ≤20 mmHg at 10 min of CPR, 96% did not attain ROSC (Return of Spontaneous Circulation)

Kern, *Resuscitation* 1988

Coronary Perfusion Pressure during CPR Adult OHCA

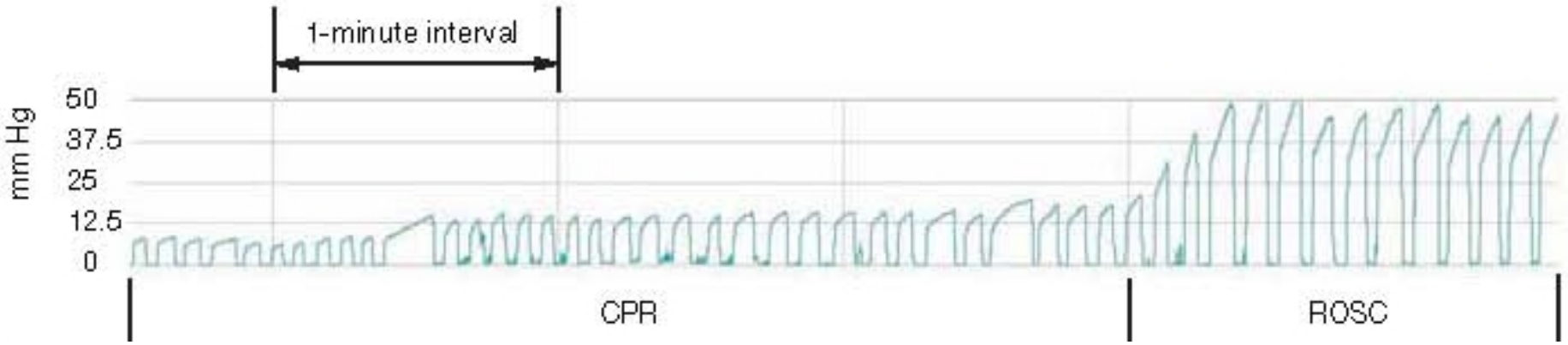


Paradis, JAMA 1990

CPR Quality

- **Physiologic Parameters**
  - Quantitative waveform capnography
    - If $PETCO_2$ <10 mm Hg attempt to improve CPR quality
  - Intra-arterial pressure
    - If relaxation phase (diastolic) pressure <20 mm Hg attempt to improve CPR quality

ACLS
ETCO2 to detect ROSC

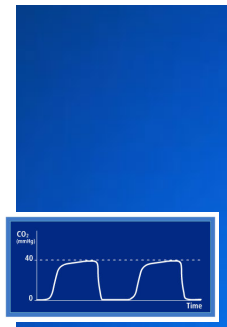


Surviving 96 minutes of CPR

- 54 yo male with witnessed sudden cardiac arrest
- Immediate bystander CPR and VF
- Defibrillation & drugs with minimally interrupted CPR
- ~ 20 minutes post-arrest: intubated
- ROSC after 96 minutes of CPR but comatose
- Transported to Mayo Clinic for post-resuscitation care
- Discharged neurologically intact 10 days later
- NPR: Why did you continue so long?
- Roger White: ETCO2 remained high showing good blood flow

The amount of expired CO_2 ($ETCO_2$) represents brain perfusion

CO_2 is expired through the breath

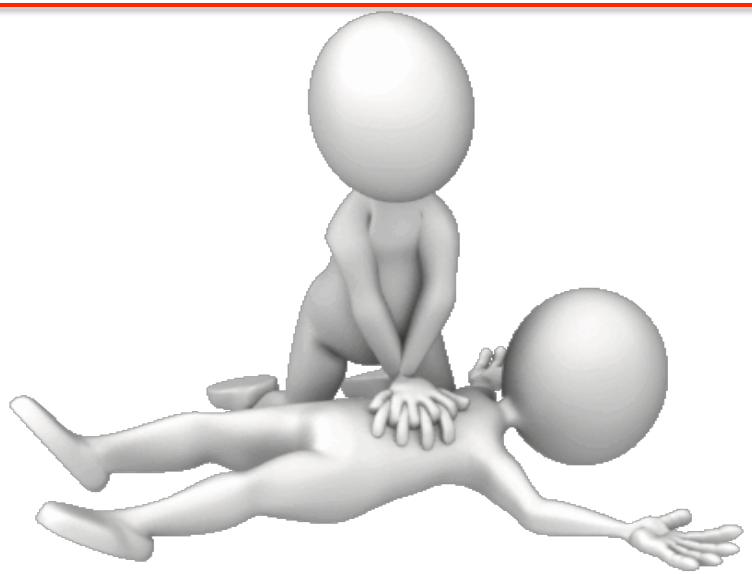


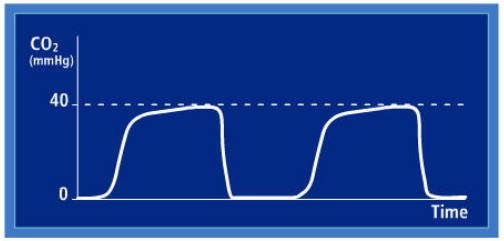
The chest is compressed

CO_2 moves from the pulmonary artery to the alveolus

Blood flows to the coronaries, the body and the brain

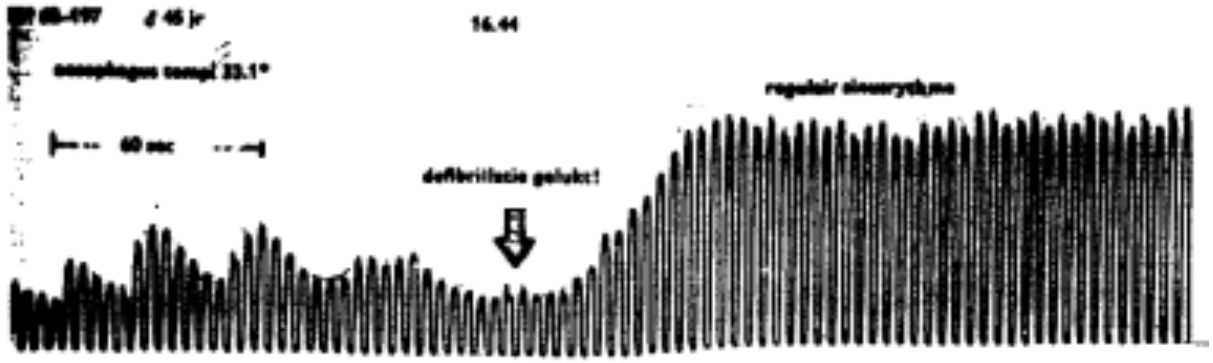
CO_2 returns from the tissues to the heart (the pulmonary artery)



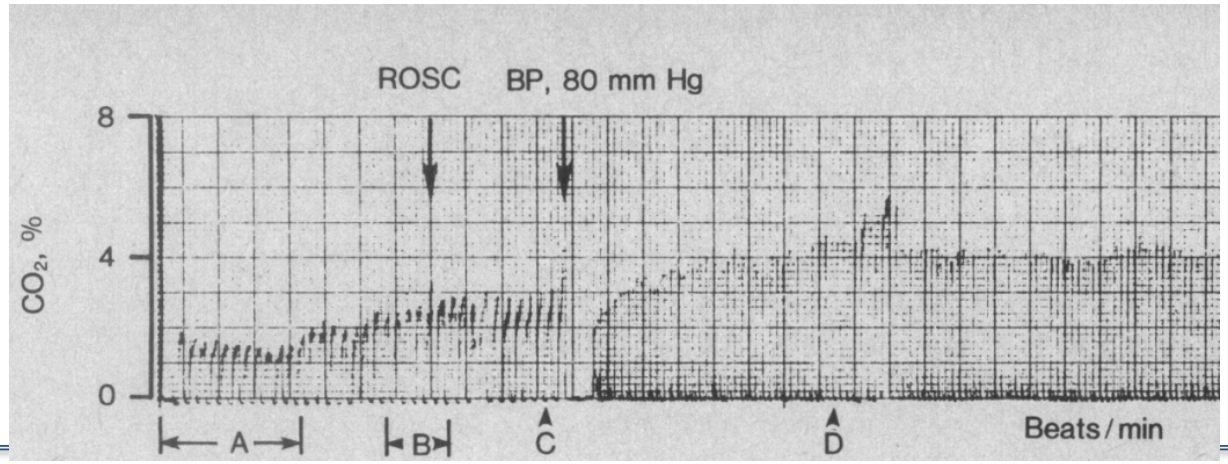


What does the literature say about $ETCO_2$ during CPR?

Case reports of $ETCO_2$ during ALS



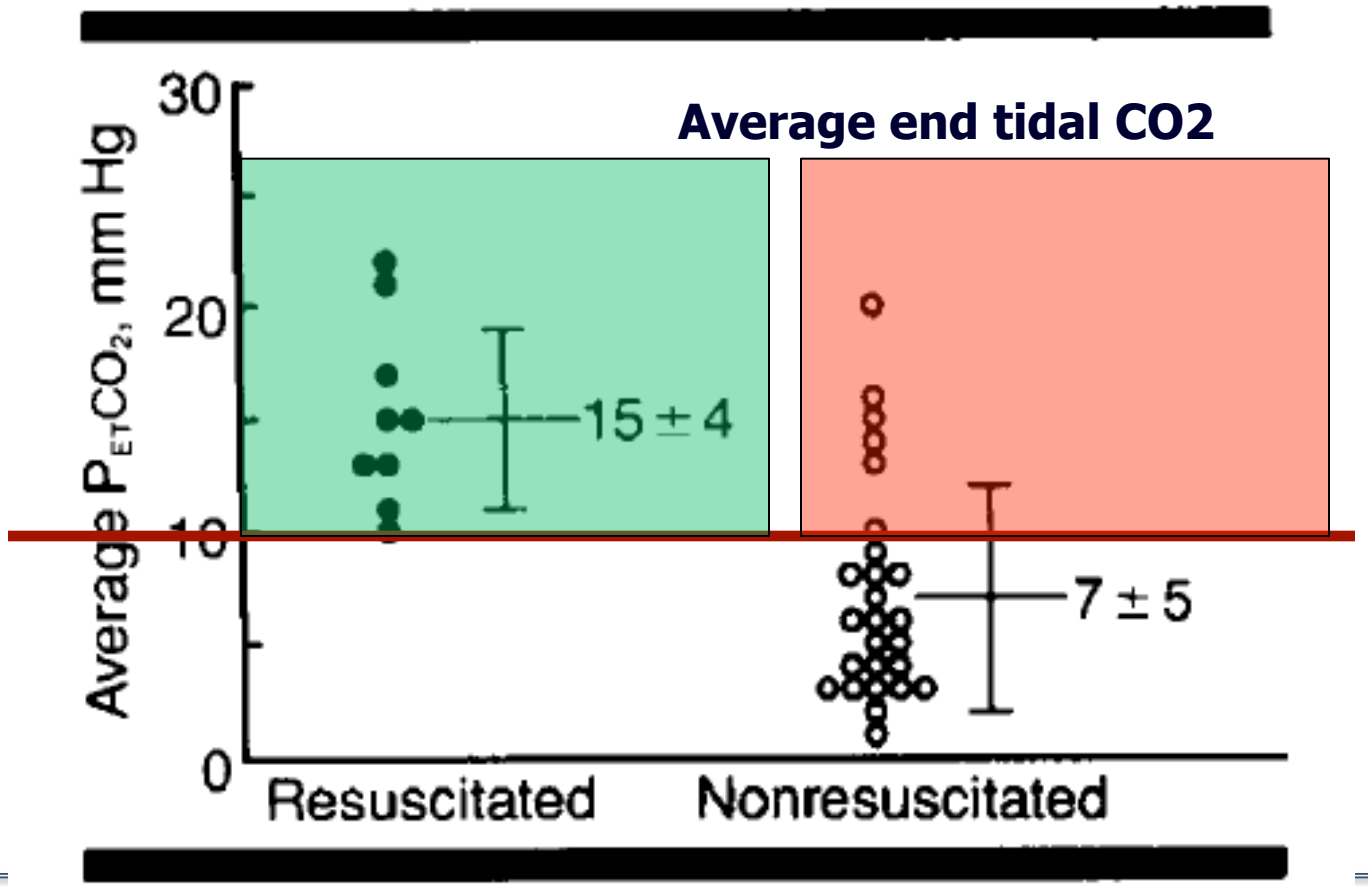
Kalenda, Resuscitation 1978



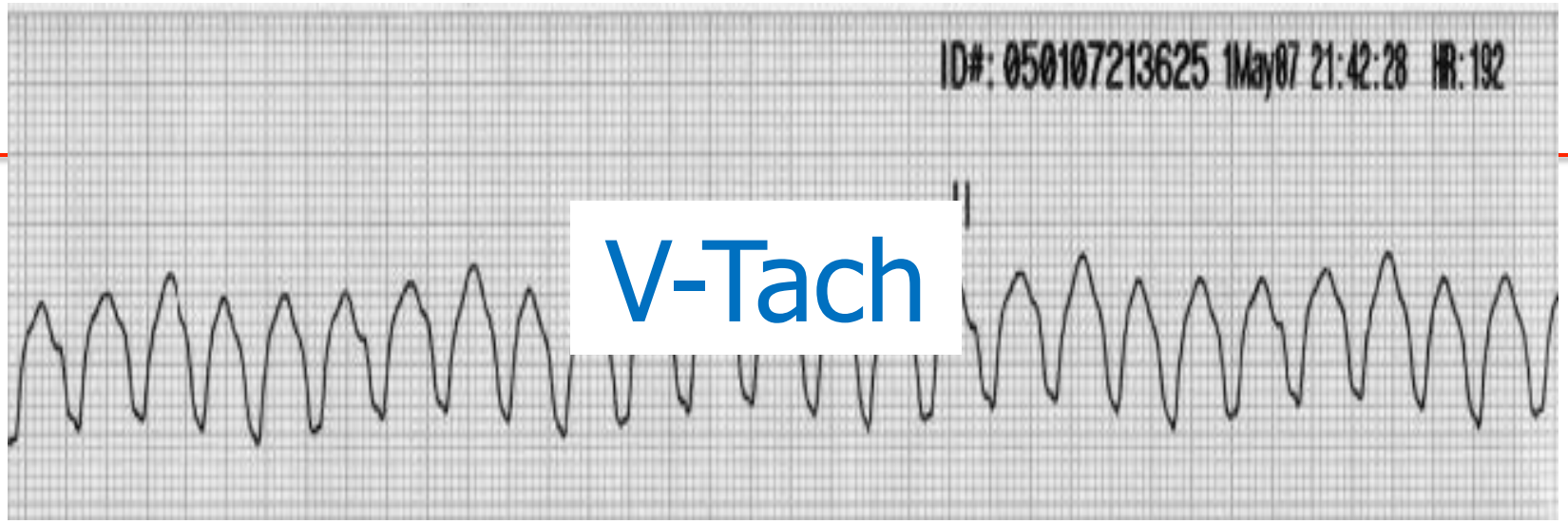
Garnett, JAMA 1987

ETCO2 in adult OHCA

Sanders, JAMA 1989



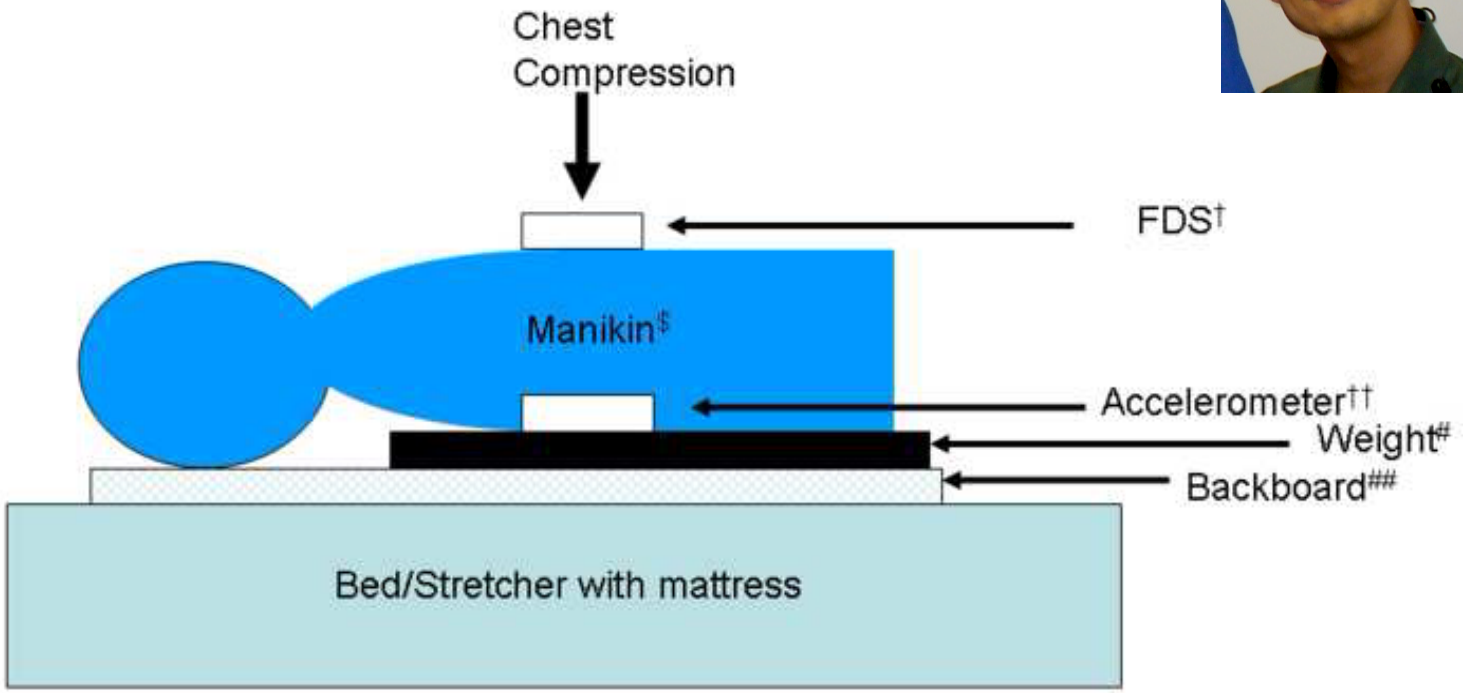
Sanders et. al., JAMA 1989


ID#: 050107213625 1May07 21:42:28 HR:192
V-Tach


2X
CPR

Everything is Moving!

Figure 1: Description of CPR reconstruction



FDS†: Force and deflection monitor placed over the lower half of sternum

Accelerometer††: Reference deflection monitor placed on the spine of manikin

Weight#: Weight is added under the manikin to be 1/2 of patient's weight (estimated torso weight).

Backboard##: Standard CPR board was placed where it was actually placed during CPR.

Manikin$: Resusci Anne (Laerdal Medical, Stavanger, Norway)

Nishisaki, Resuscitation 2009

Flat line ECG during CPR

- Asystole with no CC's
  - 50% of time
    - Wik, JAMA 2005
    - Valenzuela, Circulation 2005
- ECG leads dislodged

Conclusion

- We can and should monitor CPR
- Recognition of cardiac arrest
  - Gasping
  - Pulse check
- BP and CVP (CoPP): gold standard
- ETCO2
- Artifacts/problems

Mechanical CPR

Quality of CPR Delivered is Better with Mechanical CPR*

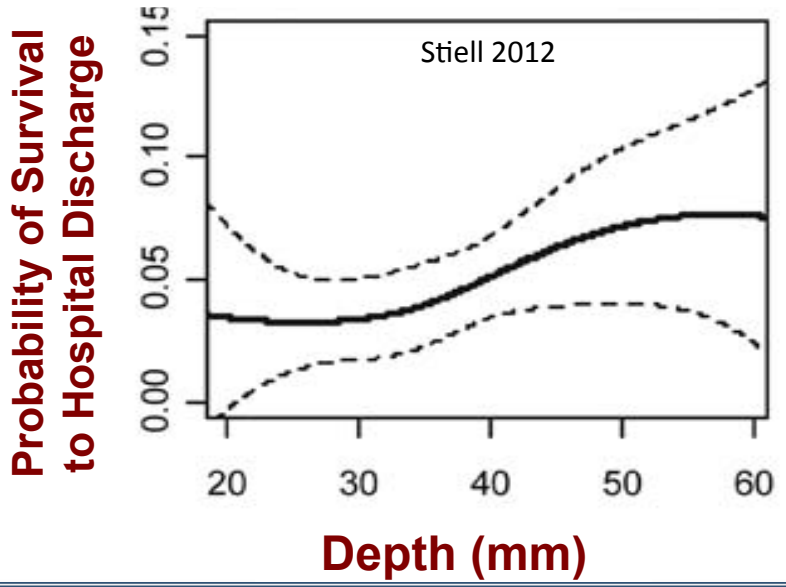
Parameter	Mechanical CPR	Manual CPR	P Value
Correct compressions	99%	59%	P<0.001
Depth	99%	79%	P<0.001
Pressure point	100%	79%	P<0.001
Complete release	100%	97%	P<0.001
“Hands off” time	46 seconds	106 seconds	P<0.001

*Putzer G, et al. Am J Emerg Med 2013 Feb;31(2):384-9. (LUCAS Device)

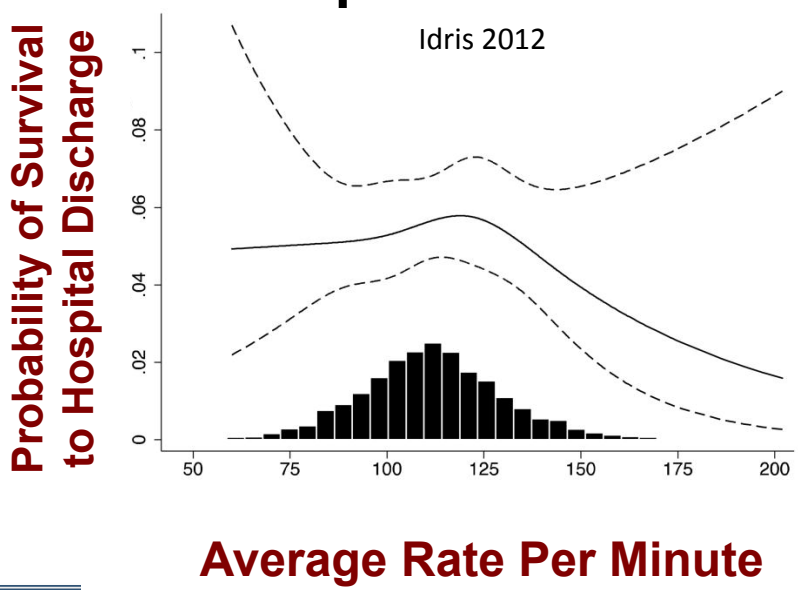
Variable Quality of CPR

- Wide variations in practice even in the best EMS systems (ROC)
- Variable compression depth and rate limit blood flow and worsens outcomes

Compression Depth

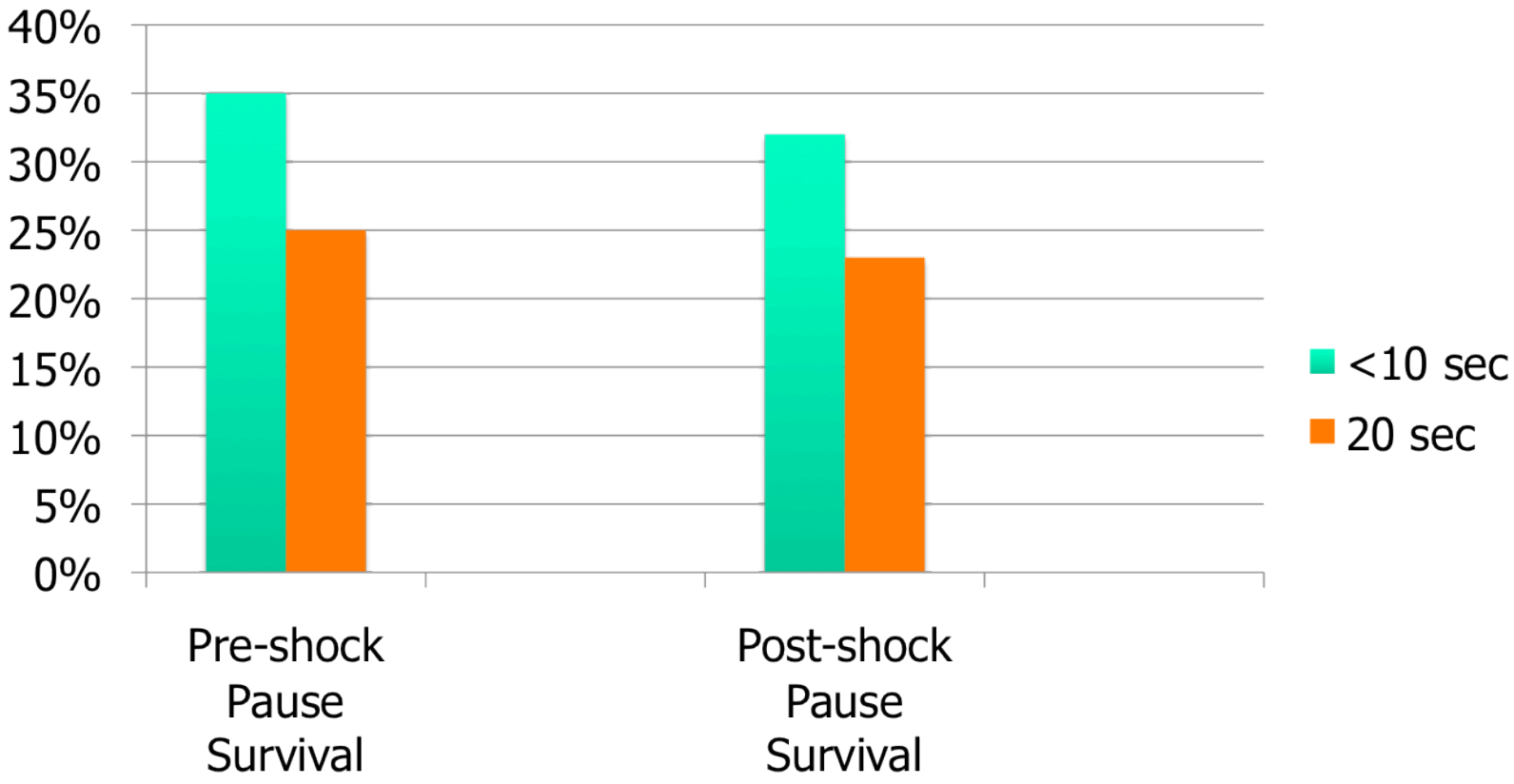


Compression Rate



Variations in CPR quality strongly linked to outcomes

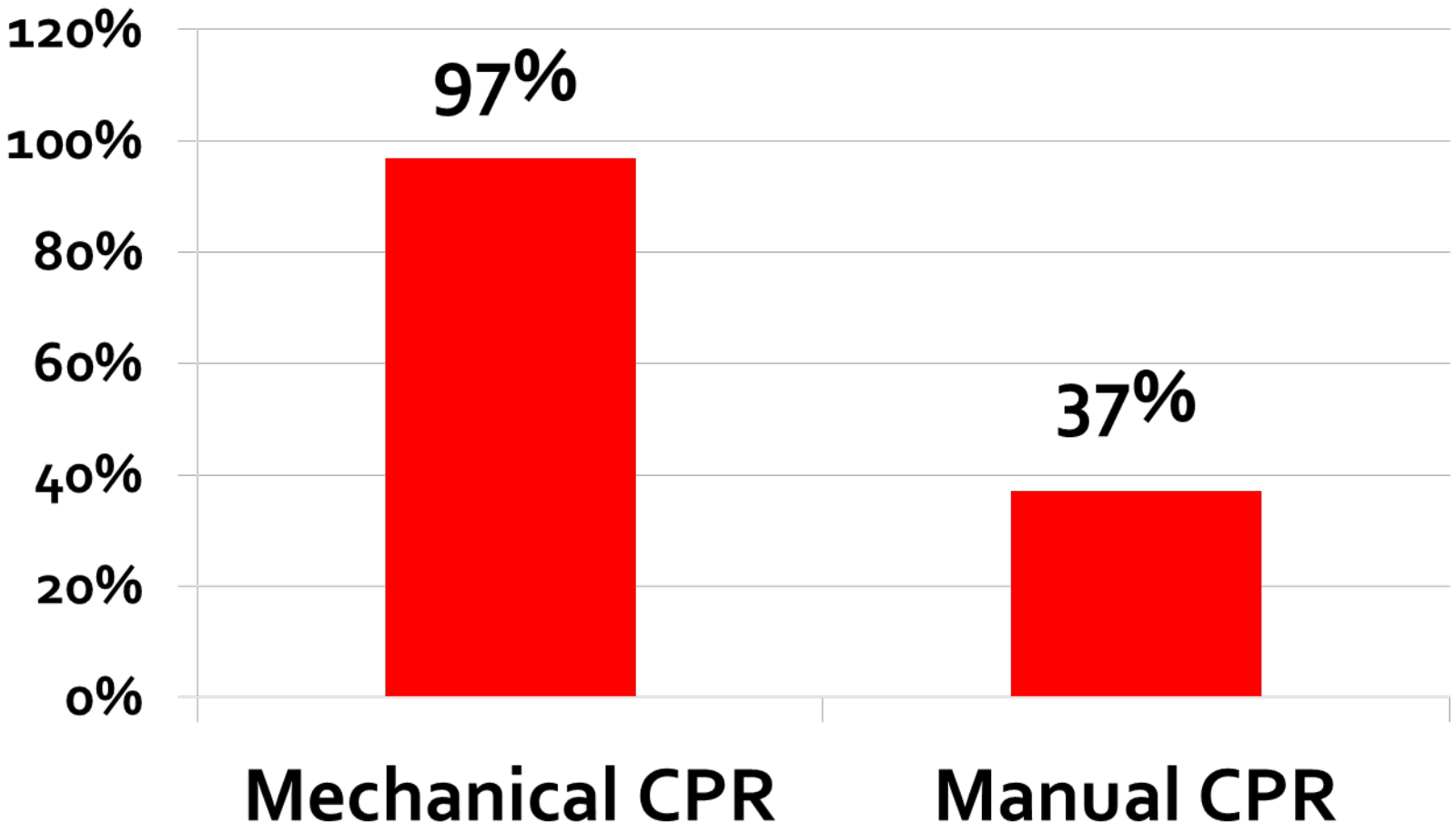
Chest Compression Pause for Shock: Decreased Survival with Pause >10 Seconds



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

Key variables

Quality of Compressions
AHA Standards



Stapleton E. *Quality of CPR During Transport.* JEMS 1991Sep;16(9):63-4, 66, 68

Transport

Patient Transport in EMS

- Mechanical CPR is the only way to provide high-quality CPR during transport and in closed spaces*
- Safety*
  - Ambulance personnel must provide CPR without being restrained by seatbelts or other protection
  - Ambulance personnel are at least 4 times more likely to have a fatal or incapacitating injury

*Putzer G, et al. Am J Emerg Med 2013 Feb;31(2):384-9.
*Becker L, et al. Accid Anal Prev 2003;35(6):941-8.
*Slattery DE, et al. Prehosp Emerg Care 2009;13(3):388-97.

Patient Transport in EMS and cath lab

- Can provide life-sustaining circulation in carefully selected patients refractory to successful resuscitation transported to the catheterization laboratory to reopen blocked arteries*
- Mechanical CPR used for cardiac arrest in the cath lab*

*Dumas F, Cariou A, Manzo-Silberman S, et al. Immediate percutaneous coronary intervention is associated with better survival after out-of-hospital cardiac arrest: insights from the PROCAT (Parisian Region Out of hospital Cardiac ArresT) registry. Circ Cardiovasc Interv. 2010;3(3):200-207.

*Garot P, Lefevre T, Eltchaninoff H, et al. Six-month outcome of emergency percutaneous coronary intervention in resuscitated patients after cardiac arrest complicating ST-elevation myocardial infarction. Circulation. 2007;115(11):1354-1362.

*Larsen AI, Hjornevik A, Bonarjee V, Barvik S, Melberg T, Nilsen DW. Coronary blood flow and perfusion pressure during coronary angiography in patients with ongoing mechanical chest compression: a report of 6 cases. Resuscitation. 2010;81(4): 493-497.

*Grogaard HK, Wik L, Eriksen M, Brekke M, Sunde K. Continuous mechanical chest compressions during cardiac arrest to facilitate restoration of coronary circulation with percutaneous coronary intervention. J Am Coll Cardiol. 2007;50(11):1093-1094.

*Bonnemeier C, Olivecrona G, Simonis G, et al. Automated continuous chest compression for in-hospital cardiopulmonary resuscitation of patients with pulseless electrical activity: a report of five cases. Int J Cardiol. 2009;136(2):E39-E50.

PCI

Mechanical Chest Compression PCI

- 

Mechanical CPR During PCI

- Positives:
  - Uninterrupted CC-No fatigue or changing rescuers
  - Minimizes radiation exposure
  - Less crowded at the cath table
  - Better compressions
- Challenges:
  - Limited view in the straight anterior-posterior view