Pediatric Cardiac Arrest Care in 2015

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Janeway CWHP
Kids Rock
Pediatric Emergency
Conference 2015

Conflicts of interest

Financial

- None

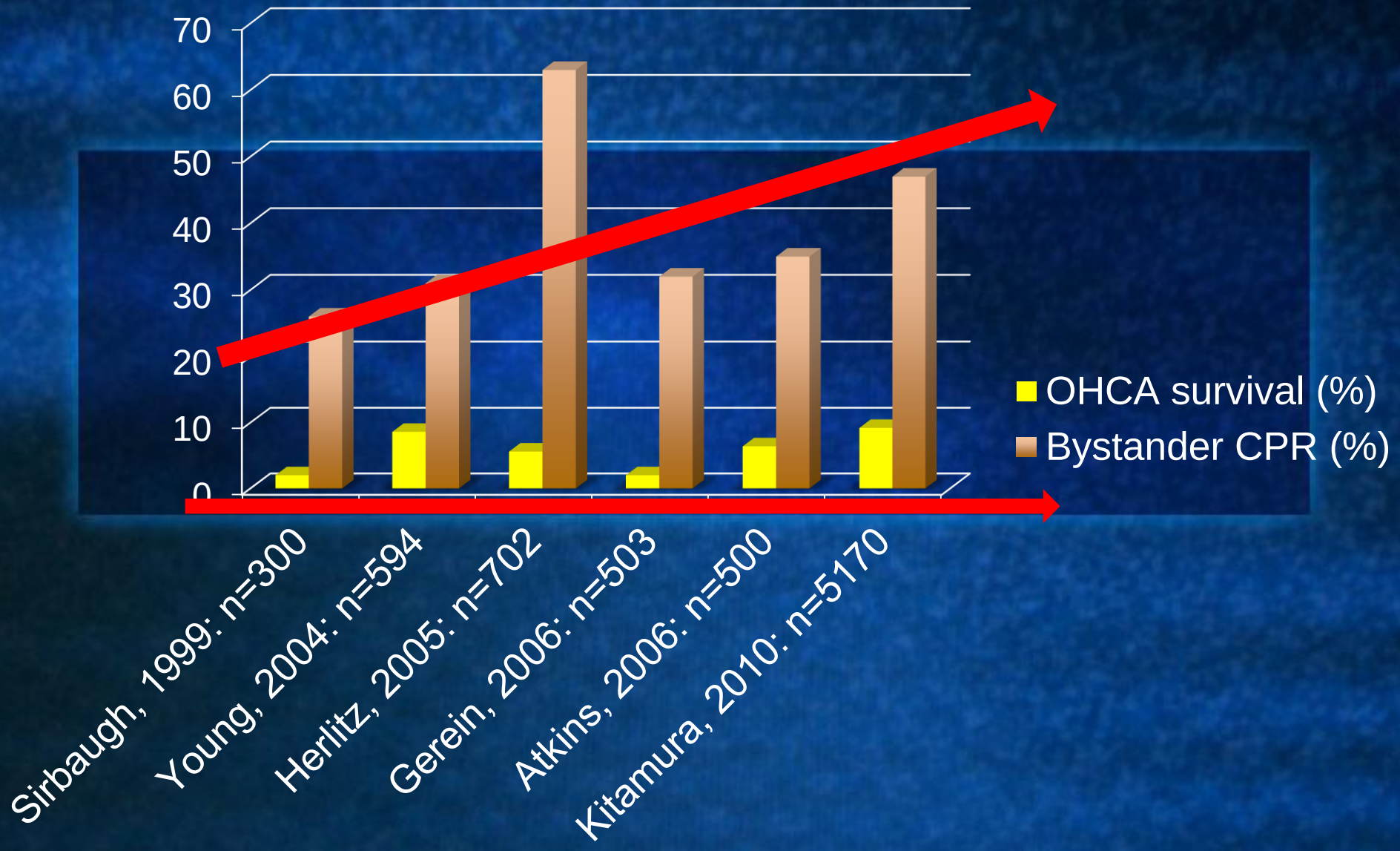
Academic/ Intellectual:

- Co-Chair, ILCOR Pediatric Task Force (2006-2015)
- Chair, AHA ‘PALS Guidelines’ Writing Group (2015)
- Heart and Stroke Foundation of Canada

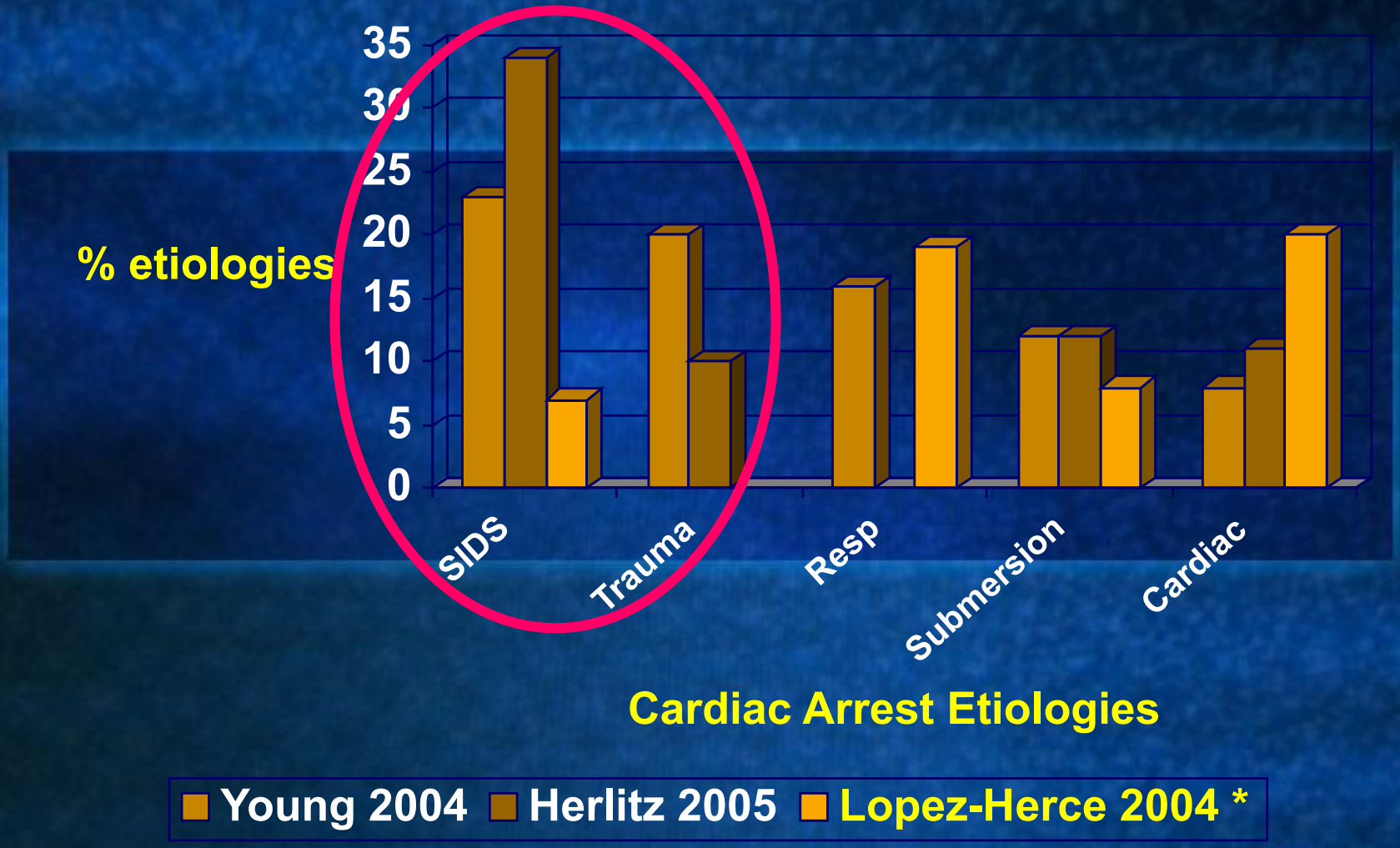
Outline

- Are outcomes from pediatric cardiac arrest improving, and if so, why?
- What are the markers of effective Pediatric CPR?
- What is the future of Pediatric CPR?

Are Outcomes from Pediatric Out-of-Hospital Cardiac Arrest (OHCA) Improving?



Why are Outcomes from Pediatric OHCA so Poor?



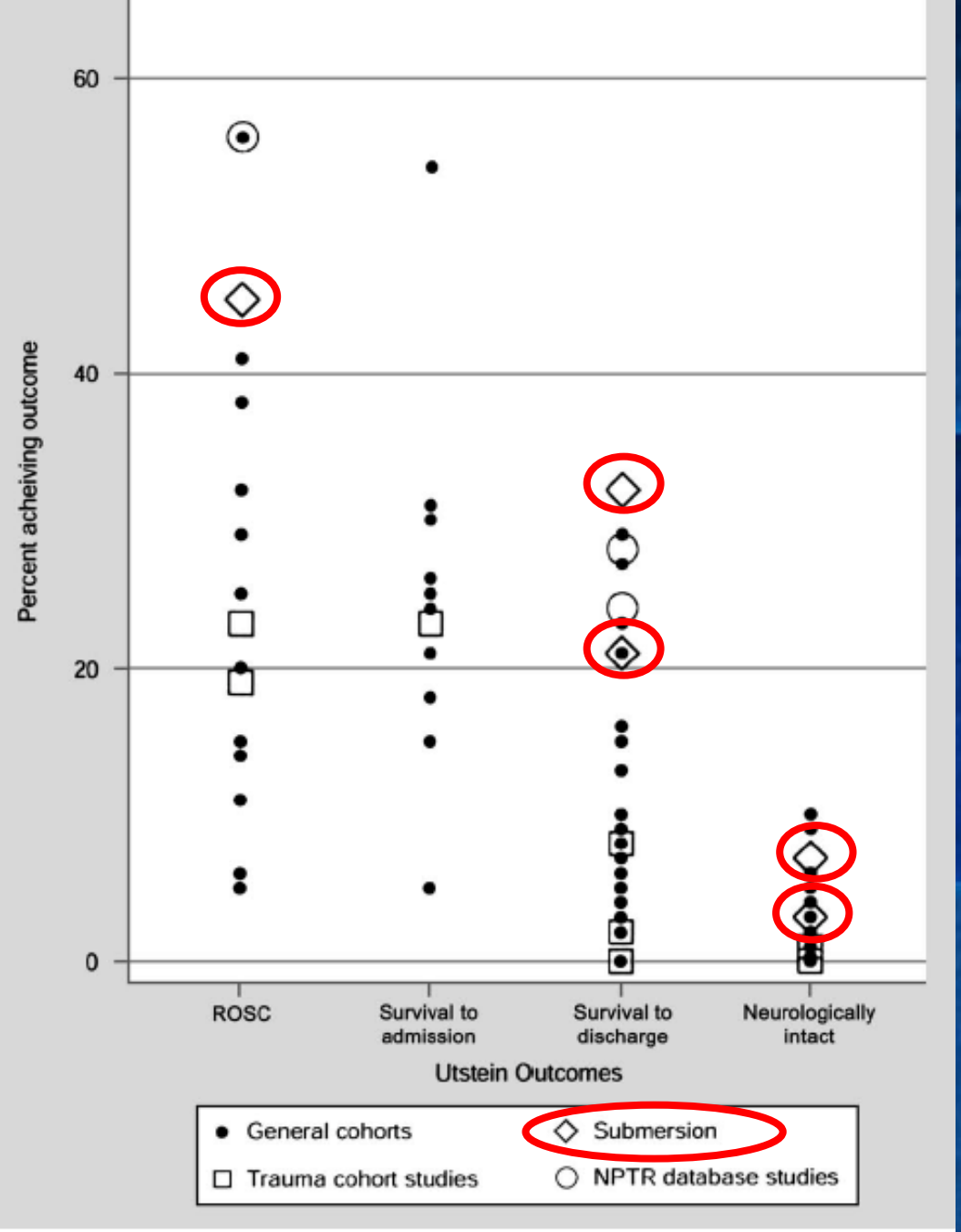


Figure 2. Range of Utstein outcomes by individual study.

Pediatric OHCA

Donoghue, 2005

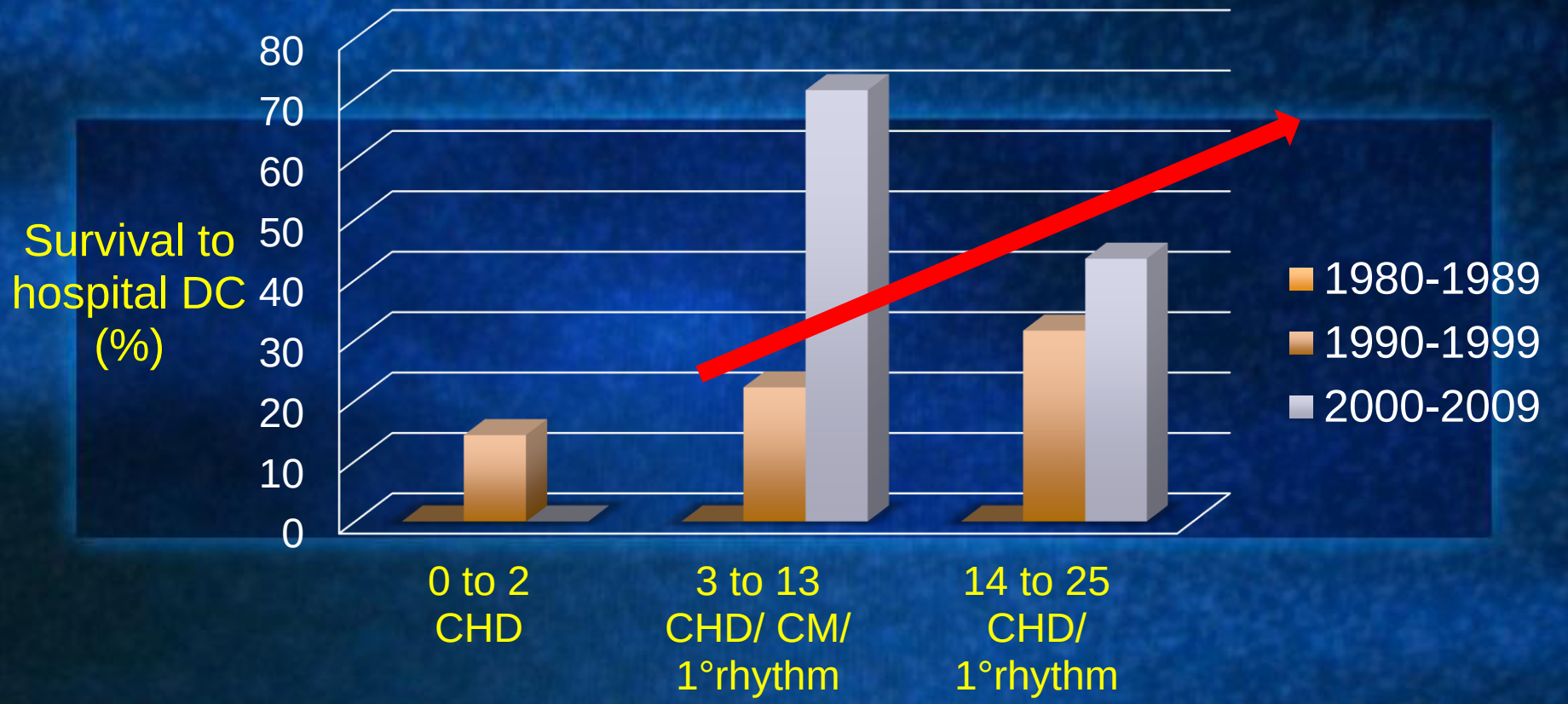
PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Withholding or Termination of Resuscitation in Pediatric Out-of-Hospital Traumatic Cardiopulmonary Arrest

Cardiac Arrest after Blunt or Penetrating Trauma

- Witnessed signs of life before cardiac arrest and with CPR ongoing or initiated within 5 minutes in the field, Immediate transportation to an ED with on-going CPR
- Unwitnessed traumatic cardiac arrest: acceptable duration of CPR (including bystander CPR) of less than 30 minutes may be considered

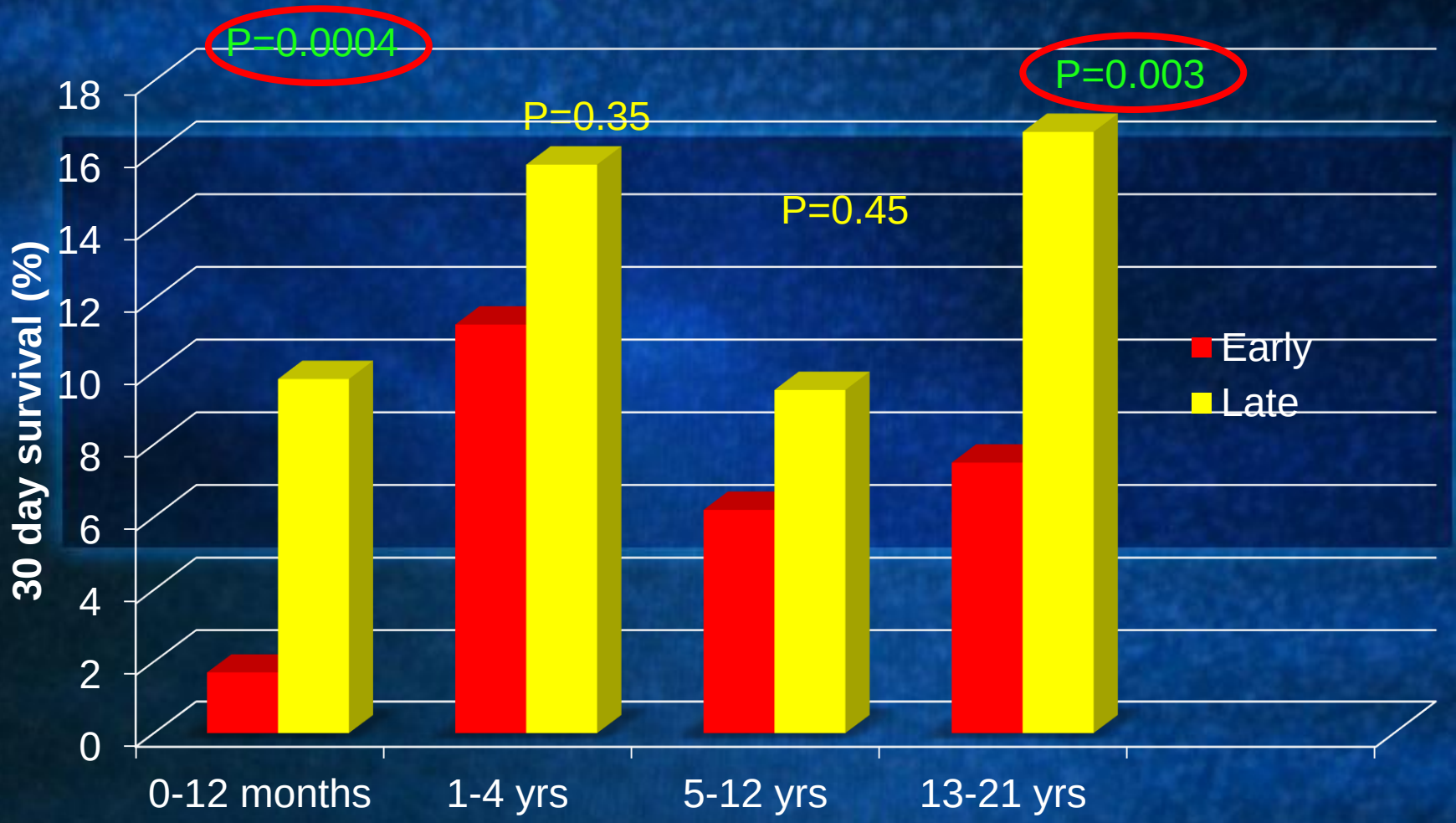
Sudden Cardiac Death
King County, Washington
Meyer et al, Circulation, 2012



- *Primary cardiac disease only*
- *< 3 min EMS response time 53% of cases*
- *51% rate of bystander CPR*

Improving Survival and Neurological Function for Younger Age Groups After Out-of-Hospital Cardiac Arrest in Sweden: A 20 Year Comparison

Gelberg, Peds CCM, In Press



- Crew-witnessed OHCAs excluded
- Trauma and SIDS included

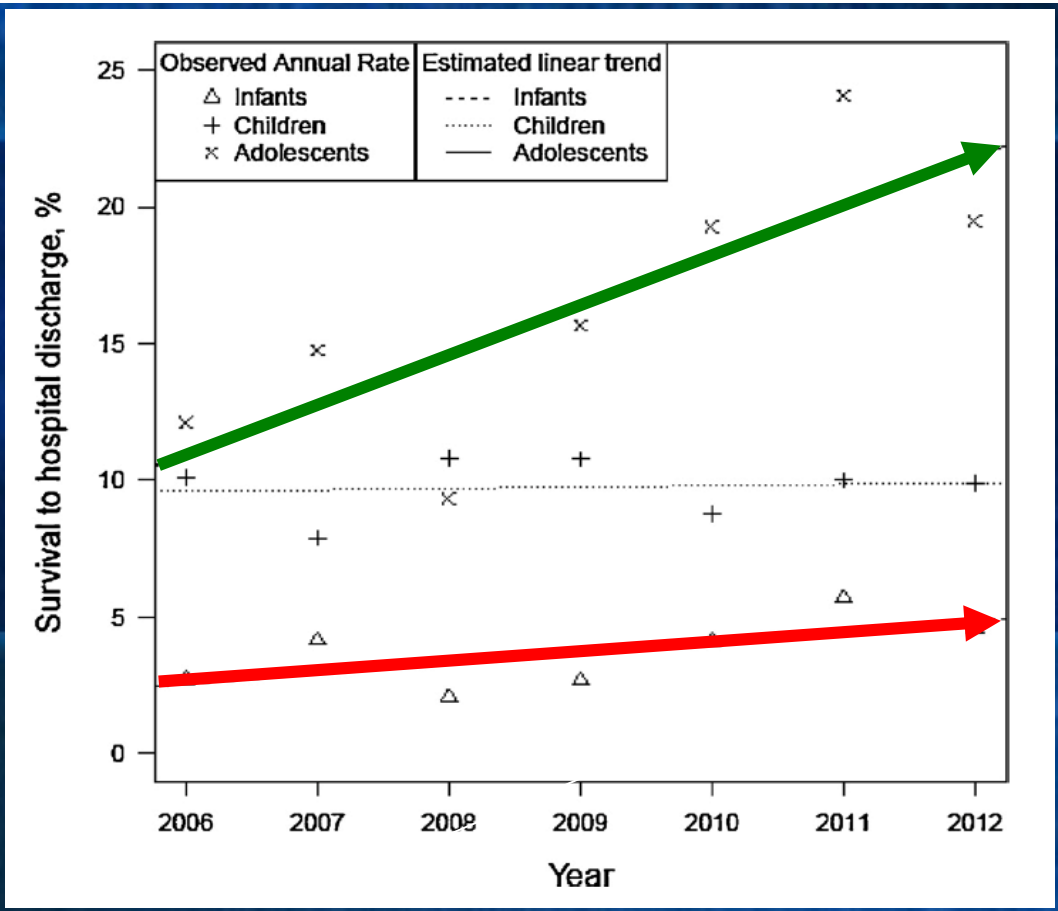
Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

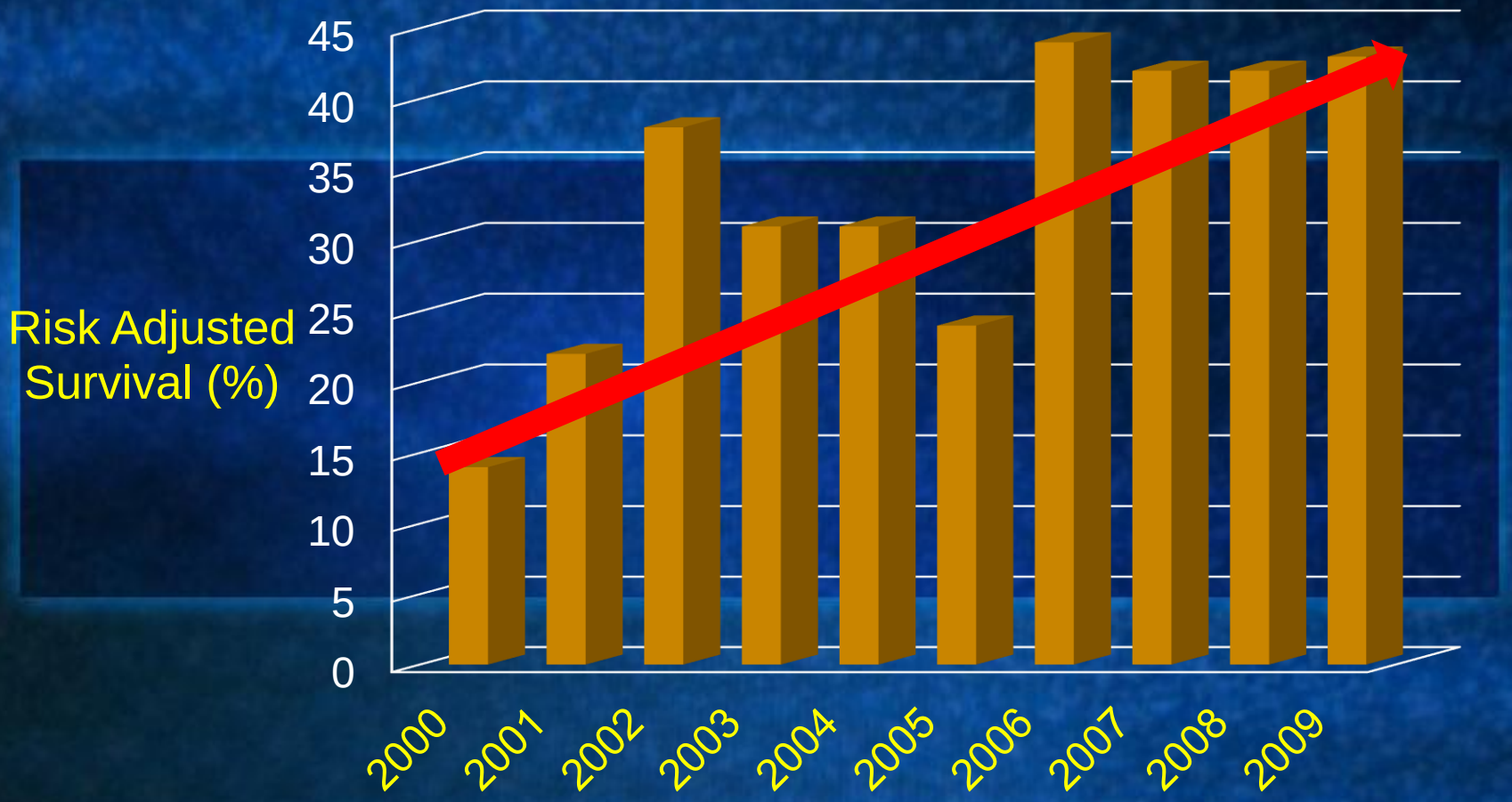
Time on the scene and interventions are associated with improved survival in pediatric out-of-hospital cardiac arrest☆



- Trauma excluded
- Crew-witnessed OHCAs included
- Includes SIDS

Pediatric IHCA Survival to Hospital D/C

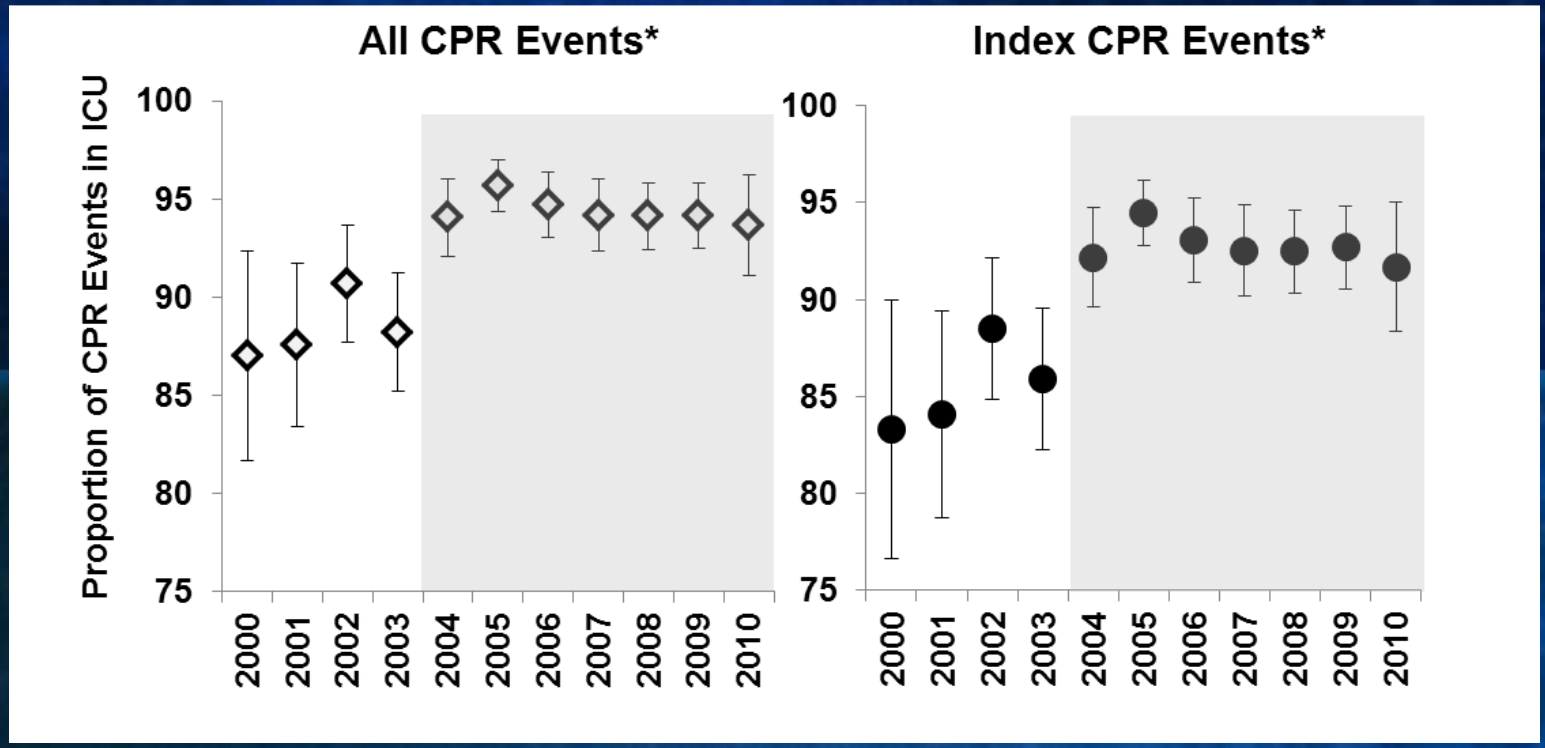
Girotra, Circ Cardiovasc Qual Outcomes, 2013



Survival trends *not* accompanied by higher rates of neurological disability among survivors over time (unadjusted *P for trend=0.32*)

Why are Outcomes from Pediatric IHCA Improving?

- Earlier movement of patients into monitored setting (PICU) pre-arrest
- Better PICU care (pre-, during and post-arrest)?



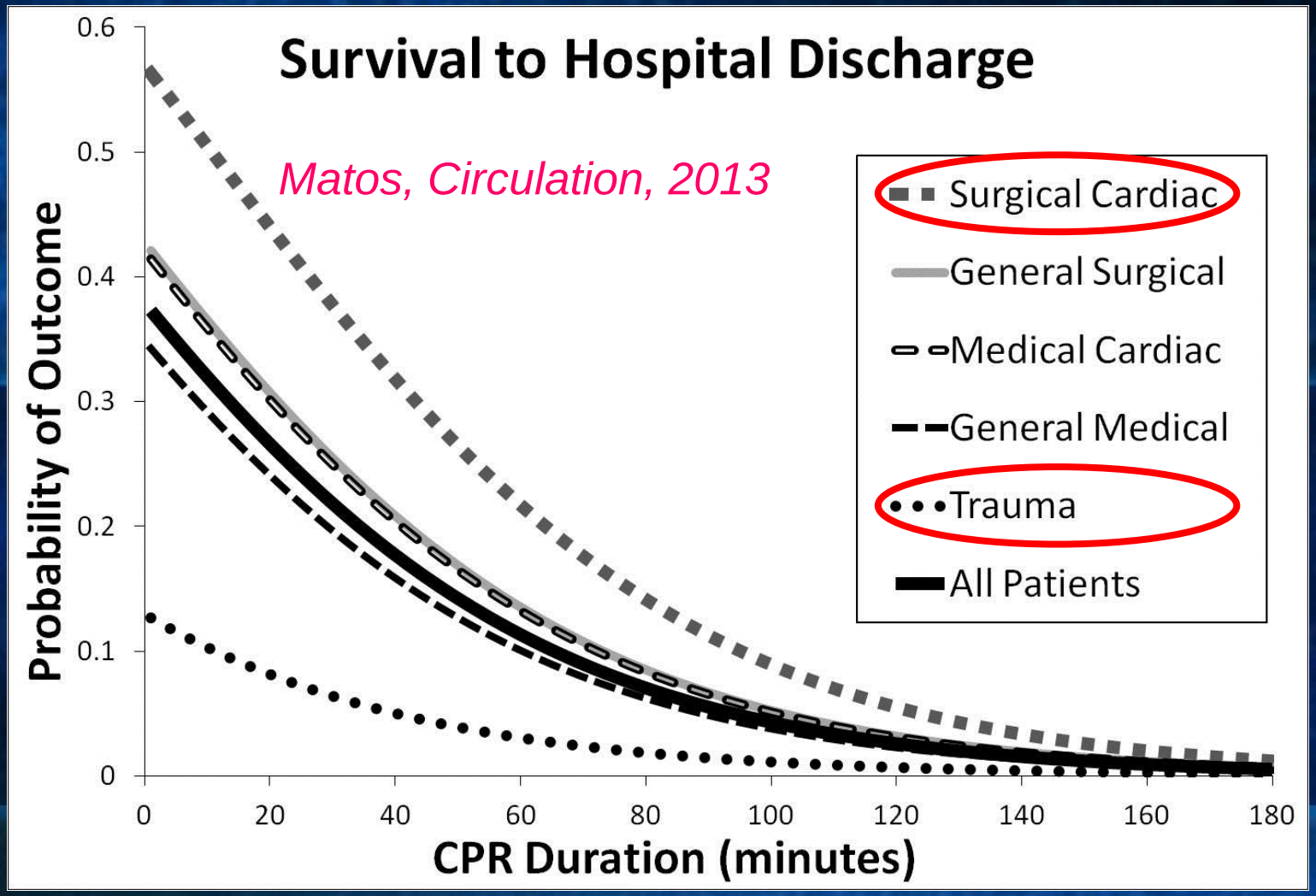
Berg et al, CCM, 2013

Duration of CPR and Illness Category Impact Survival and CNS Outcomes for IHCA

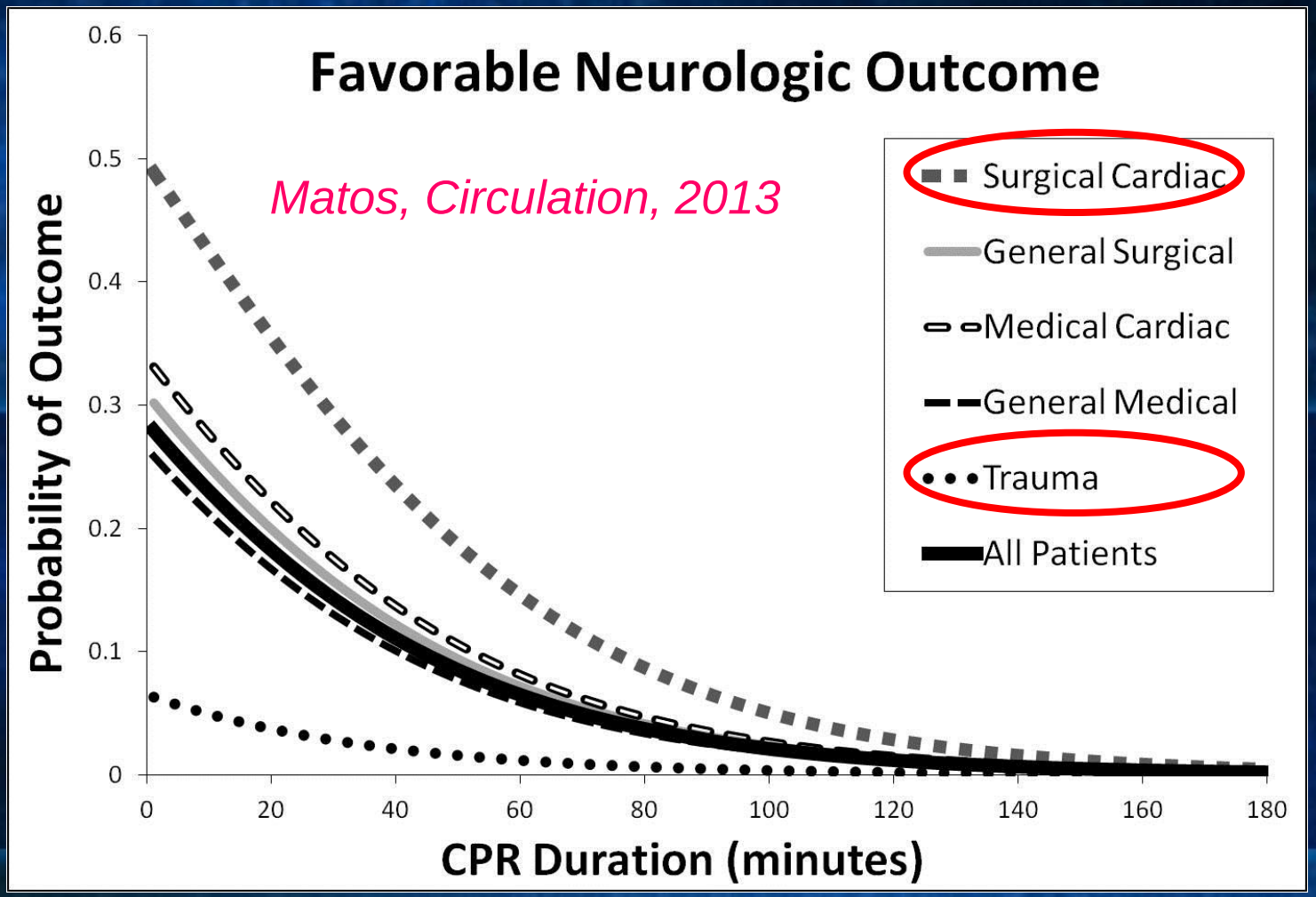
Matos, Circulation, 2013

3419 children from 328 N. American GWTG-R sites with in-hospital cardiac arrests (Jan 2000 -Dec 2009)

- Adjusted probability of survival:
  - CPR duration of 1 to 15 minutes: 41%
  - CPR duration of >35 minutes: 12%
- Among survivors, favorable neurological outcome occurred in:
  - CPR duration of 1 to 15 minutes: 70%
  - CPR duration of >35 min: 60%



- Between 1 and 15 minutes of CPR, survival decreased linearly by 2.1% per minute



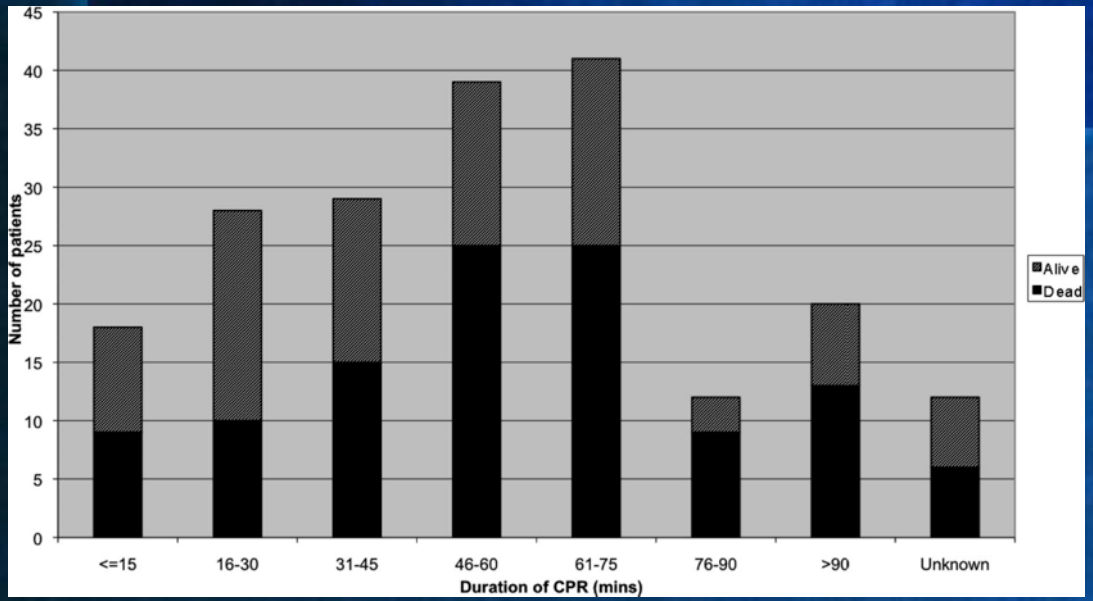
- Between 1 and 15 minutes of CPR, rates of favorable CNS outcome decreased by 1.2% per minute

ECPR: ECLS for Refractory Pediatric IHCA

Rapid-Response Extracorporeal Membrane Oxygenation to Support Cardiopulmonary Resuscitation in Children With Cardiac Disease

Kane Circulation 2010

- 180 ECPR runs in 172 patients
- 51% survived to discharge



Outcomes among neonates, infants, and children after ECPR for refractory IHCA (NRCPR)

Raymond, Peds CCM, 2010

Is High Quality CPR Making a Difference in Current Pediatric Cardiac Arrest Outcomes?

What is high quality CPR?

AHA Consensus Statement

Cardiopulmonary Resuscitation Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital

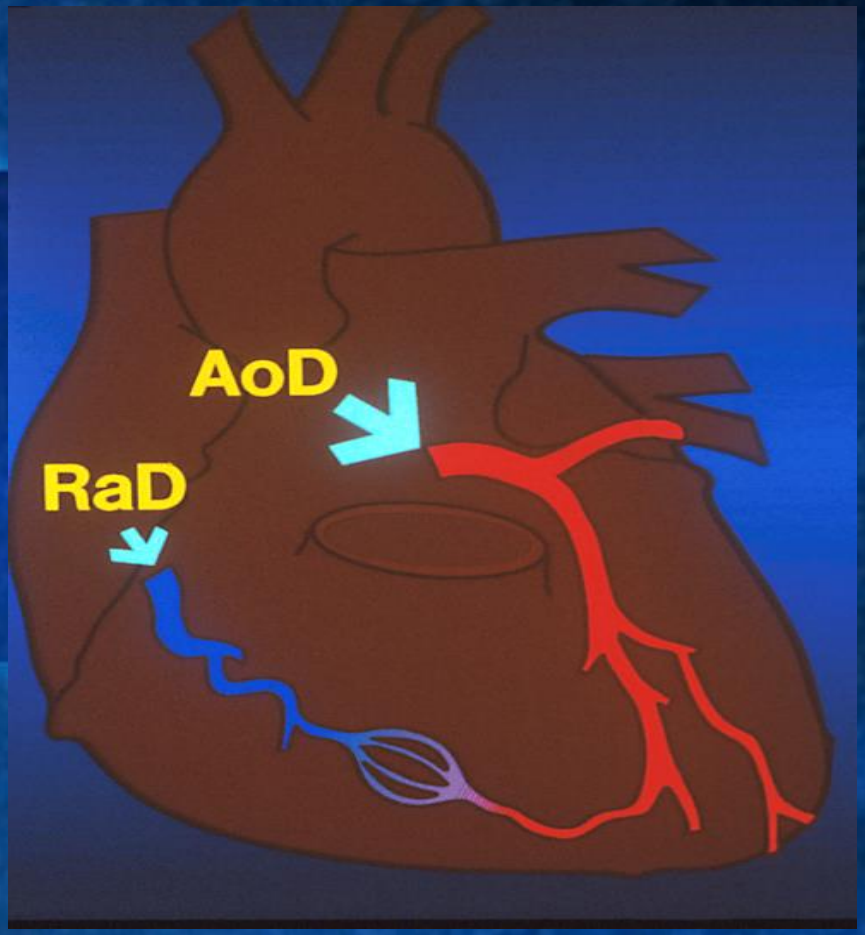
A Consensus Statement From the American Heart Association

Endorsed by the American College of Emergency Physicians

Meaney et al, Circulation, 2013

What do Chest Compressions do?

- The critical effect of chest compressions is generation of coronary artery perfusion pressure (CPP)
- CPP is the surrogate for ROSC (return of spontaneous circulation) in animal studies



Do CPR metrics correlate with CPP ?

Measuring CPR Metrics in Children

CC-Rate, Depth, Leaning, Ventilation Rate, EtC02

- Most of our current CPR metrics have (up until now) been extrapolated from animal/ adult/ pediatric (non-arrest models) data
- Accelerometer technology in new monitor-defibrillators using anterior-posterior pads allow accurate measurement (*and real-time AV feedback*) of CC rate/ depth/ leaning
- Limited pediatric clinical data exists to date to show associations between CPR

Sutton, Pediatrics, 2009

< 8 yrs. age

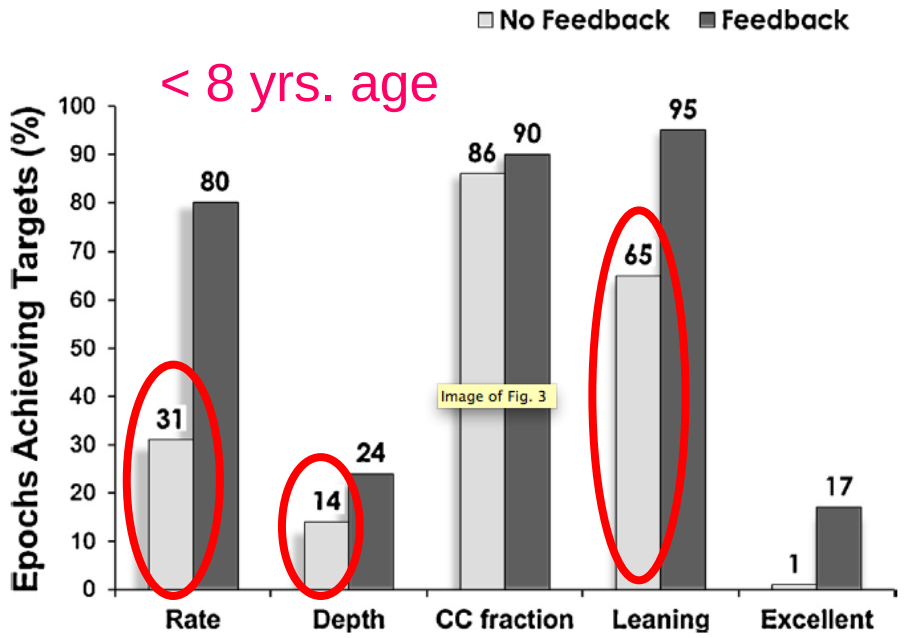


Fig. 3. Percentage of CPR epochs achieving targets for depth ≥50 mm, rate ≥100 and ≤120 CC/min, CC fraction >0.80, and leaning <20% of compressions. Excellent indicates CPR having all 4 CPR elements achieving targets.

> 8 yrs. age

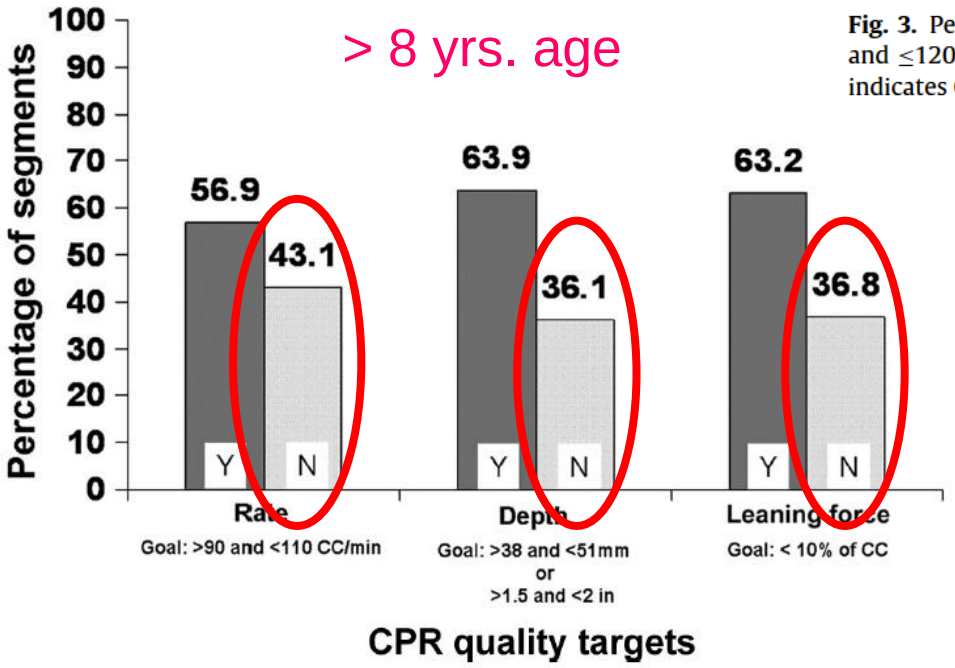
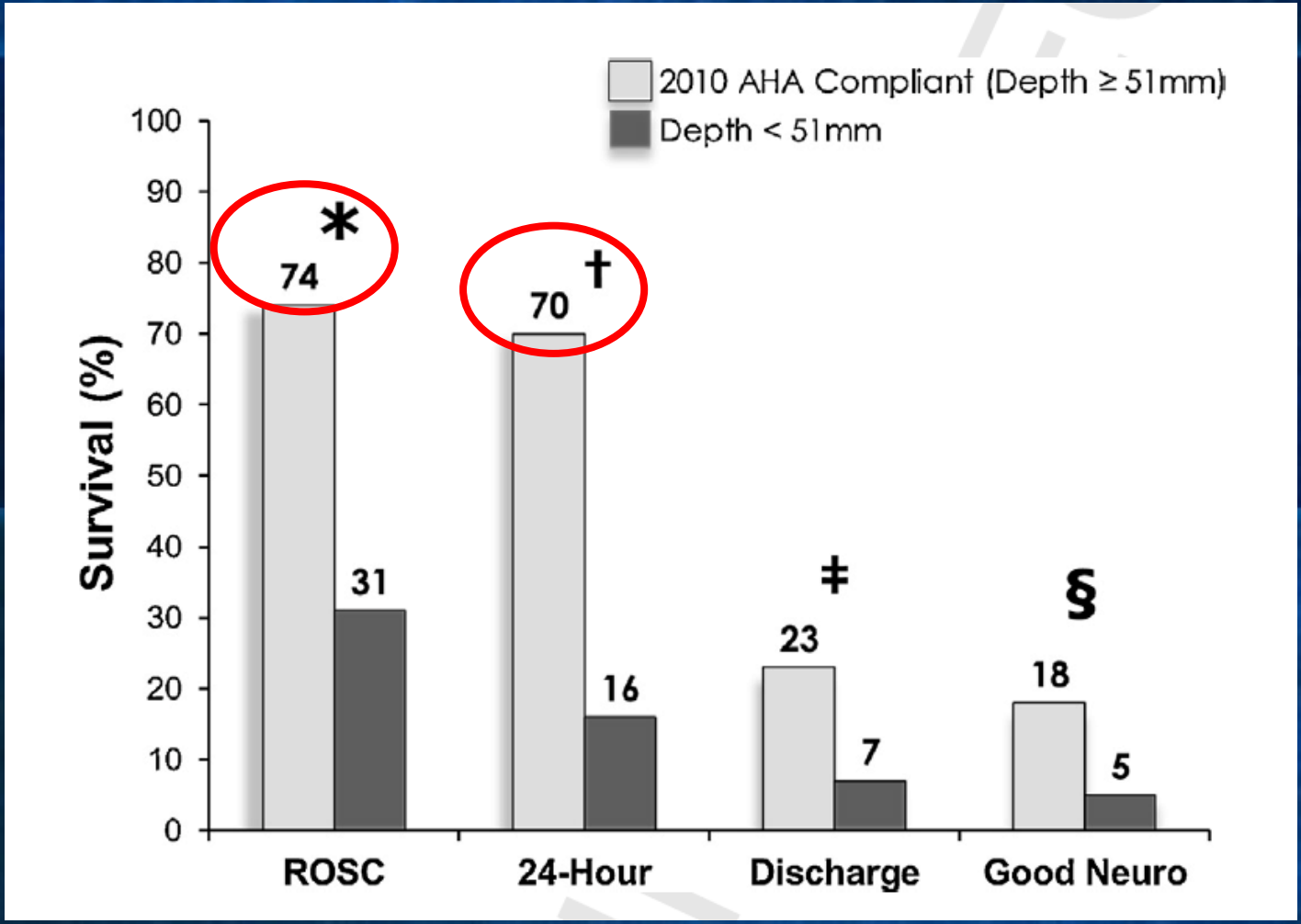


FIGURE 1
Percentage of time segments of analyzed CPR that met AHA standards. Y indicates met AHA standards; N indicates outside AHA standards.

Sutton, Resuscitation, 2013

2010 American Heart Association recommended compression depths during pediatric in-hospital resuscitations are associated with survival

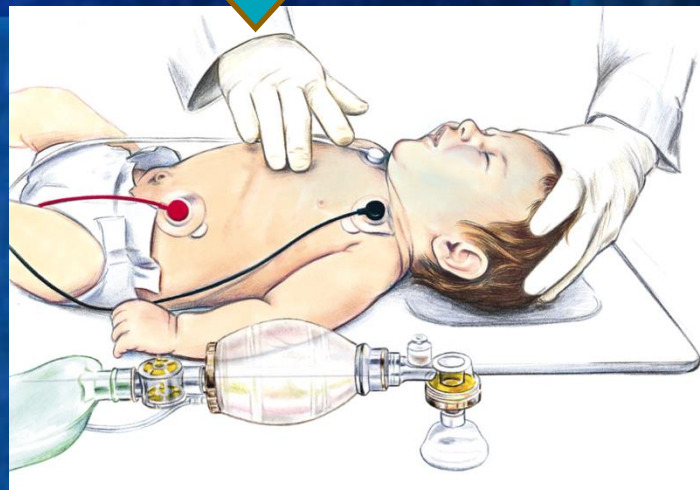
Sutton, Resuscitation, 2014

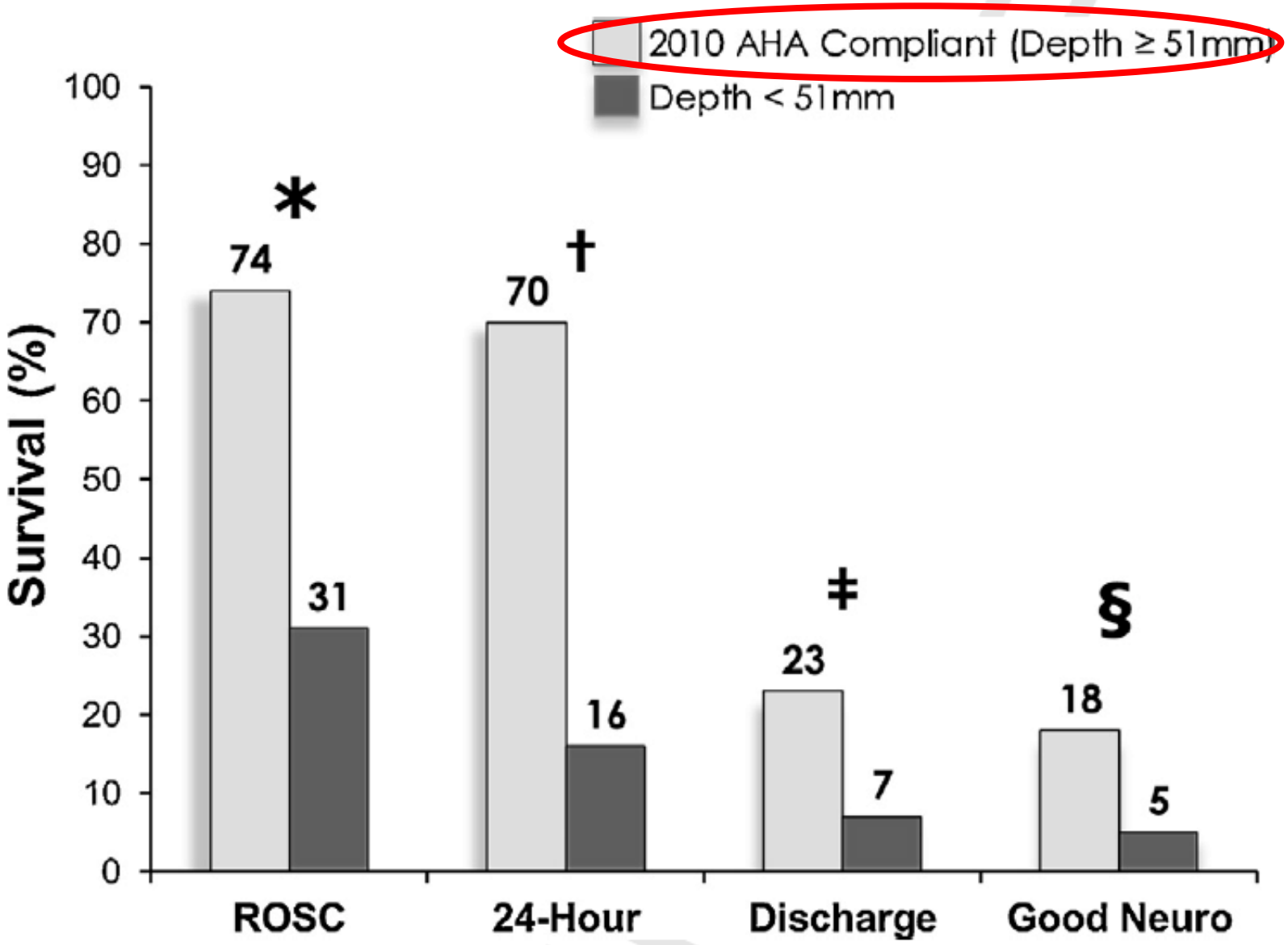


How Deep is Deep Enough?

- Compressing to an arbitrary depth (cm or % of chest diameter) is impractical and too subjective
- Better to "*Press hard*" as overly deep compressions are currently an uncommon occurrence
- Mattress compression leads to overestimation of compression depth, even when current accelerometers are used (*ie. use a back board*)

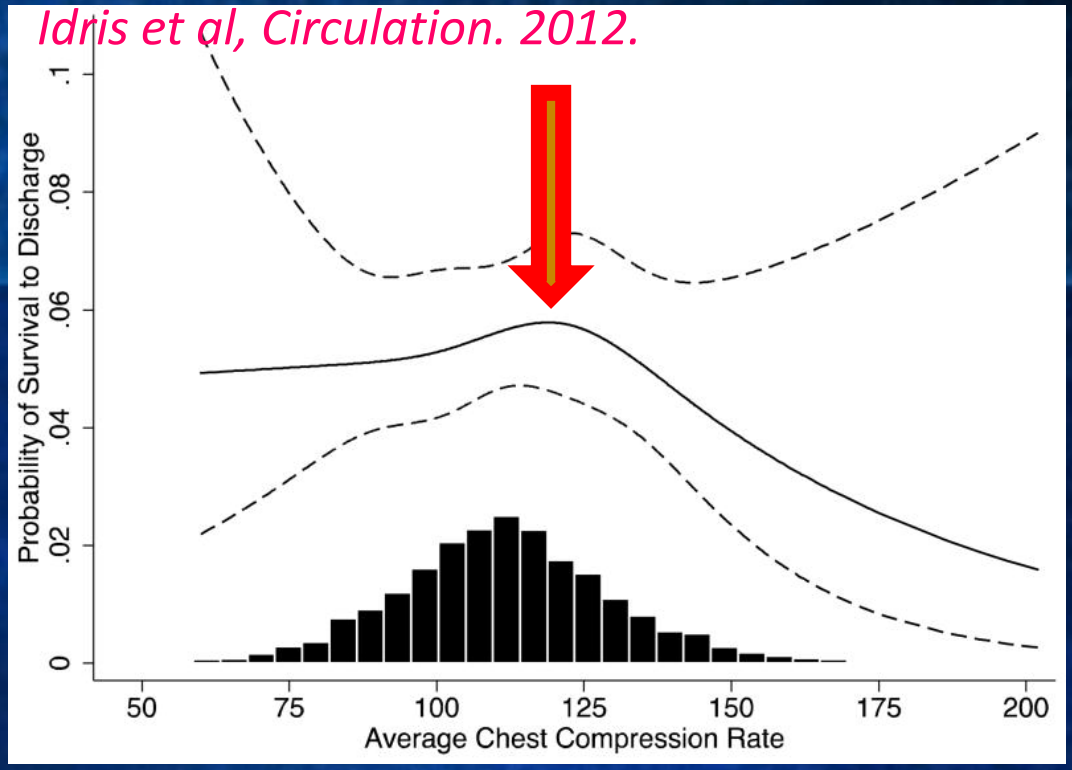
Outcome data is needed that derives from accelerometer-based and mattress compression-adjusted CPR metrics, especially from younger pts





Sutton, Resuscitation, 2014

CC rate and Quality of Pediatric CPR



Dashed lines are 95% confidence intervals

A CC-rate ≥100/min was associated with:

Diastolic BP ≥30 mmHg (OR 2.15; p< 0.001).

Sutton, Resuscitation, 2013

Leaning During CPR

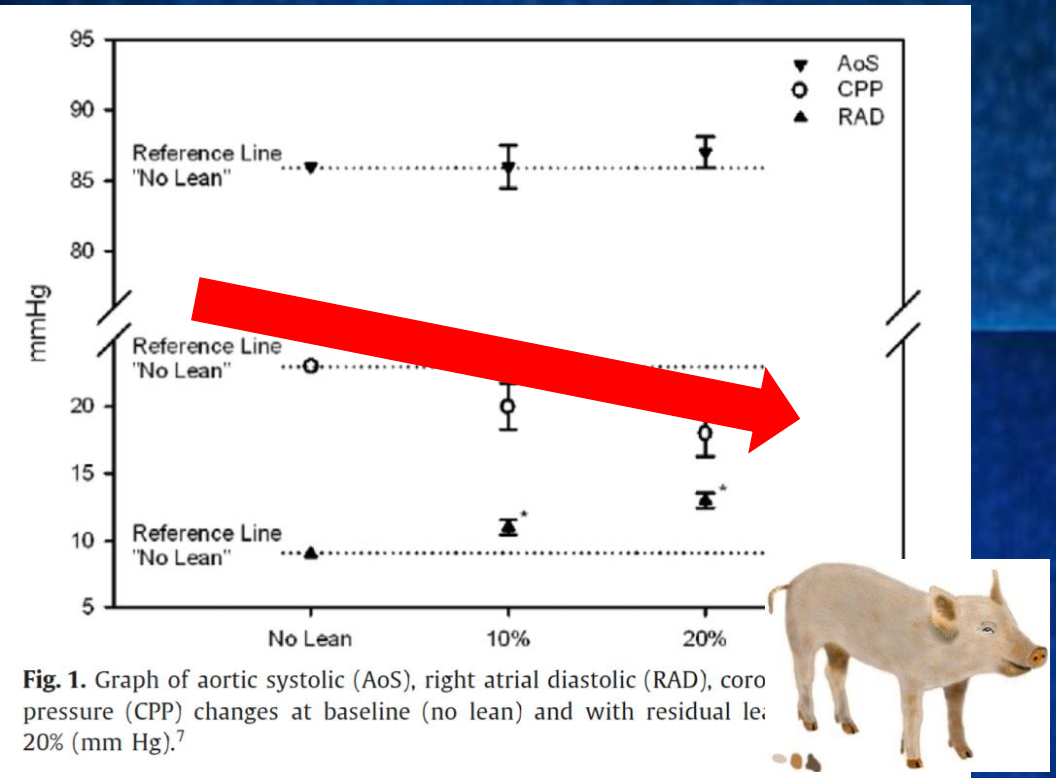


Fig. 1. Graph of aortic systolic (AoS), right atrial diastolic (RAD), coro pressure (CPP) changes at baseline (no lean) and with residual le 20% (mm Hg).[7]

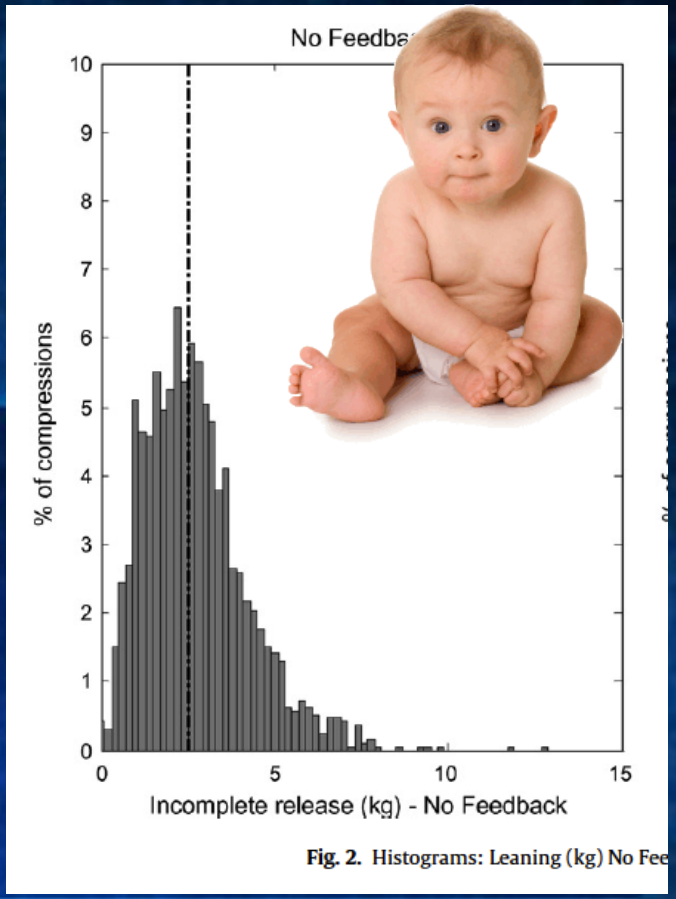


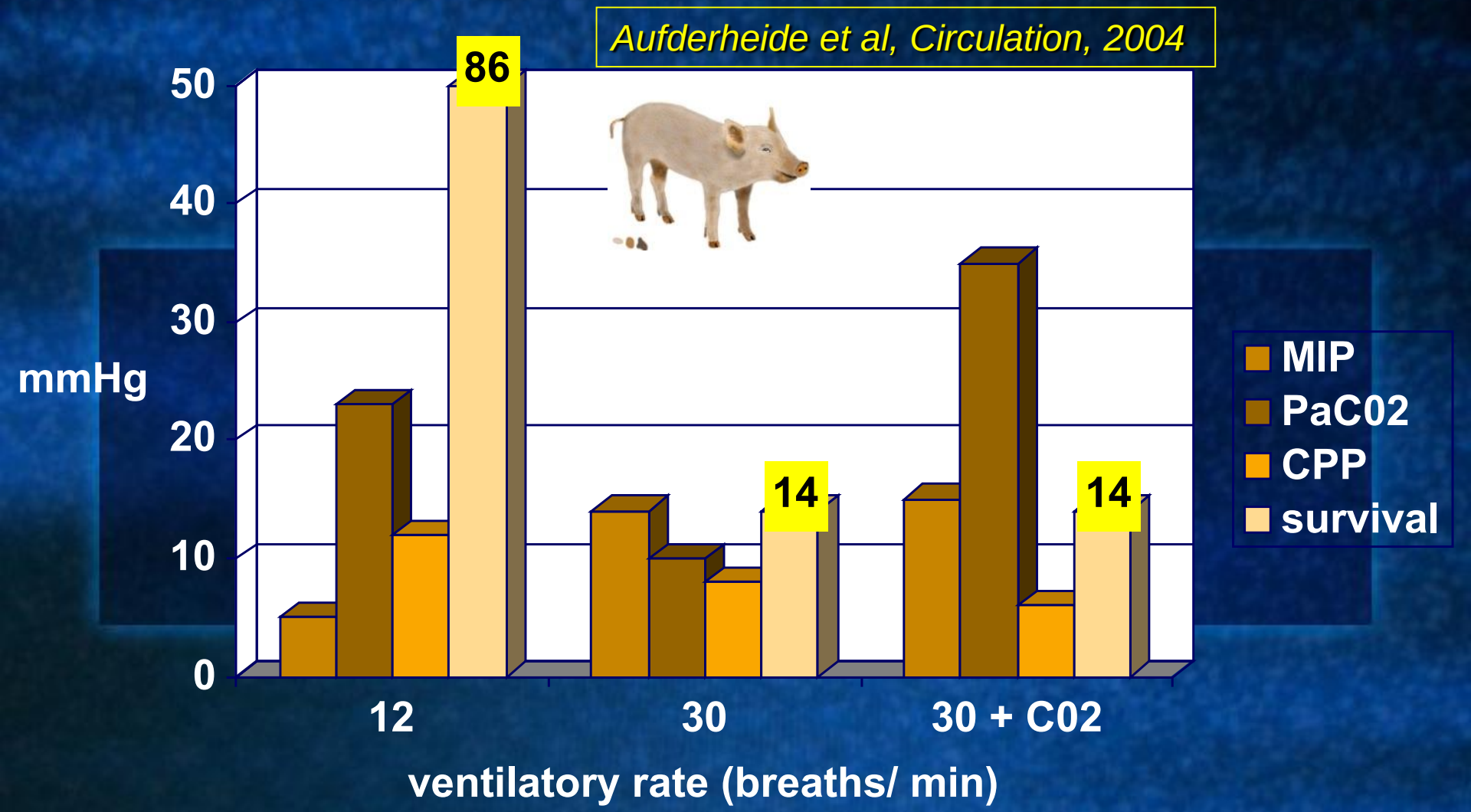
Fig. 2. Histograms: Leaning (kg) No Fee

Niles, Resuscitation, 2011

Niles, Resuscitation, 2009

Leaning during CPR reduces chest wall recoil and impedes venous return, reducing both CPP and cerebral perfusion

Killing CPR Victims with Hyperventilation?



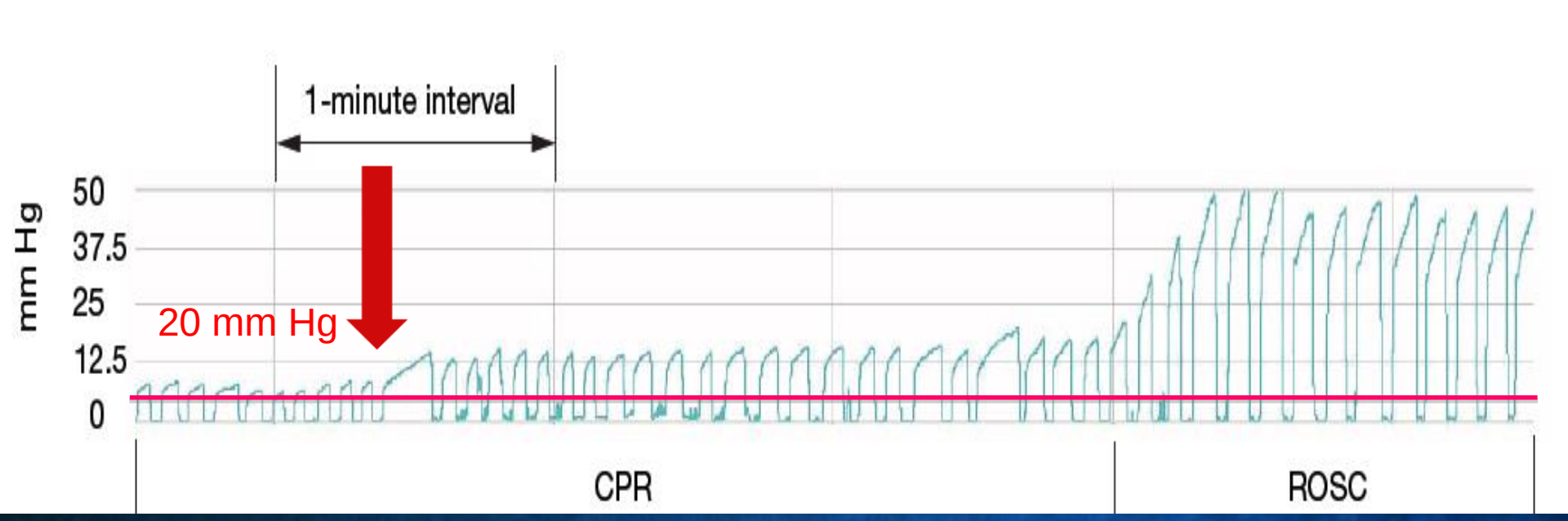
Adults and children are frequently inadvertently hyperventilated during cardiac arrest

Aufderheide, 2004; Abella, 2005; McInnes, 2011

Quantifying Physiologic Effectiveness of CCs

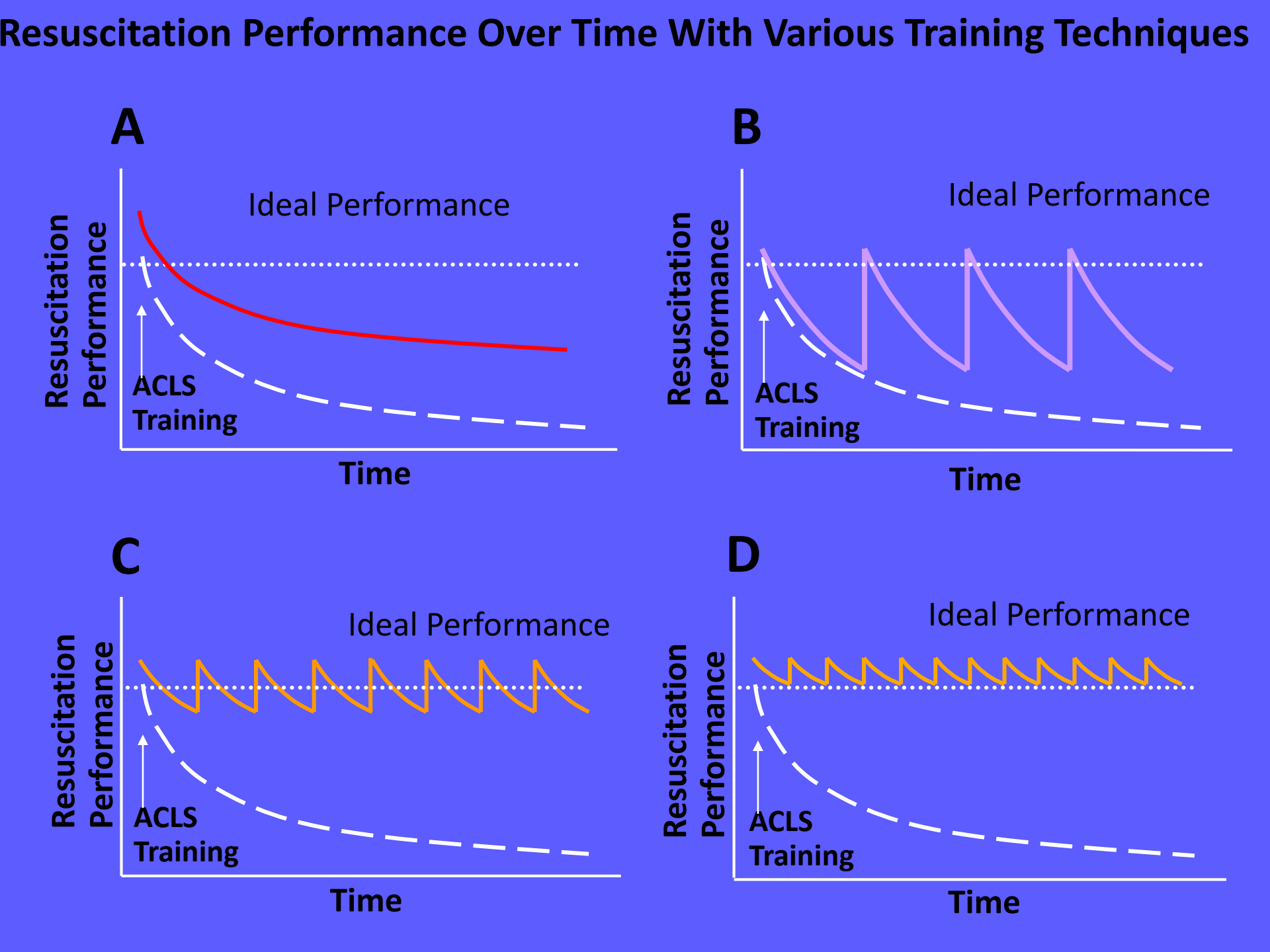
End tidal C02 is a surrogate for pulmonary blood flow and overall cardiac output, *assuming that ventilation (tidal volume/ rate) doesn't vary*

- Paucity of pediatric-specific data



What is the Future of Pediatric CPR ?

Resuscitation Performance Over Time With Various Training Techniques



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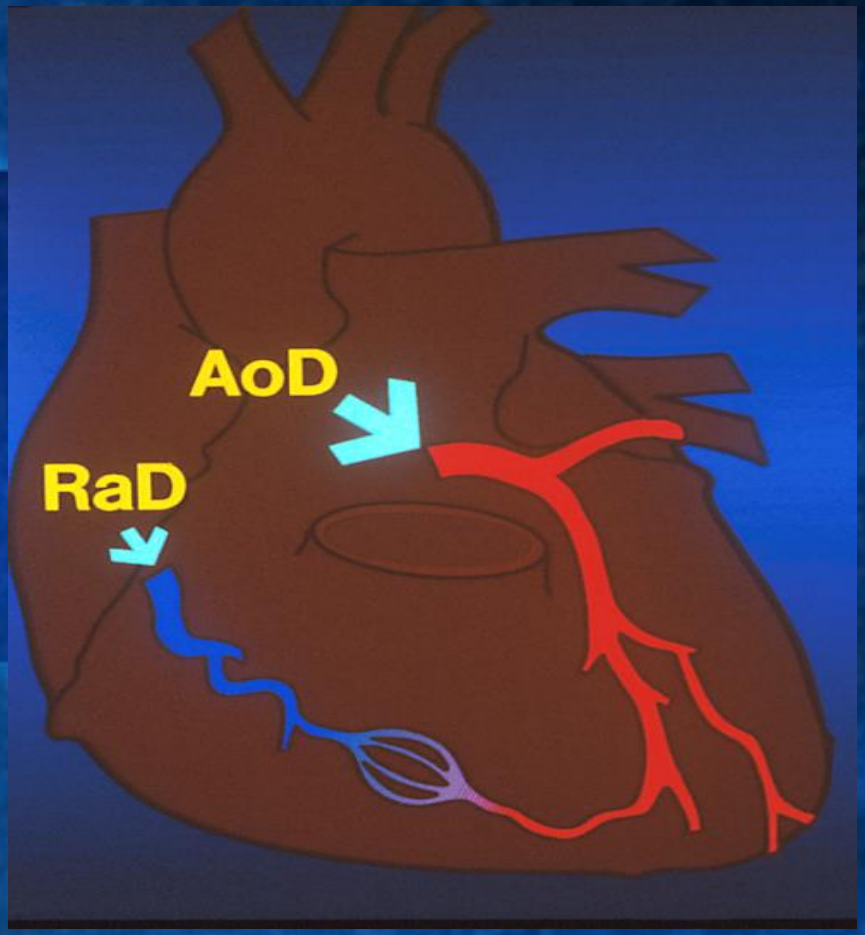
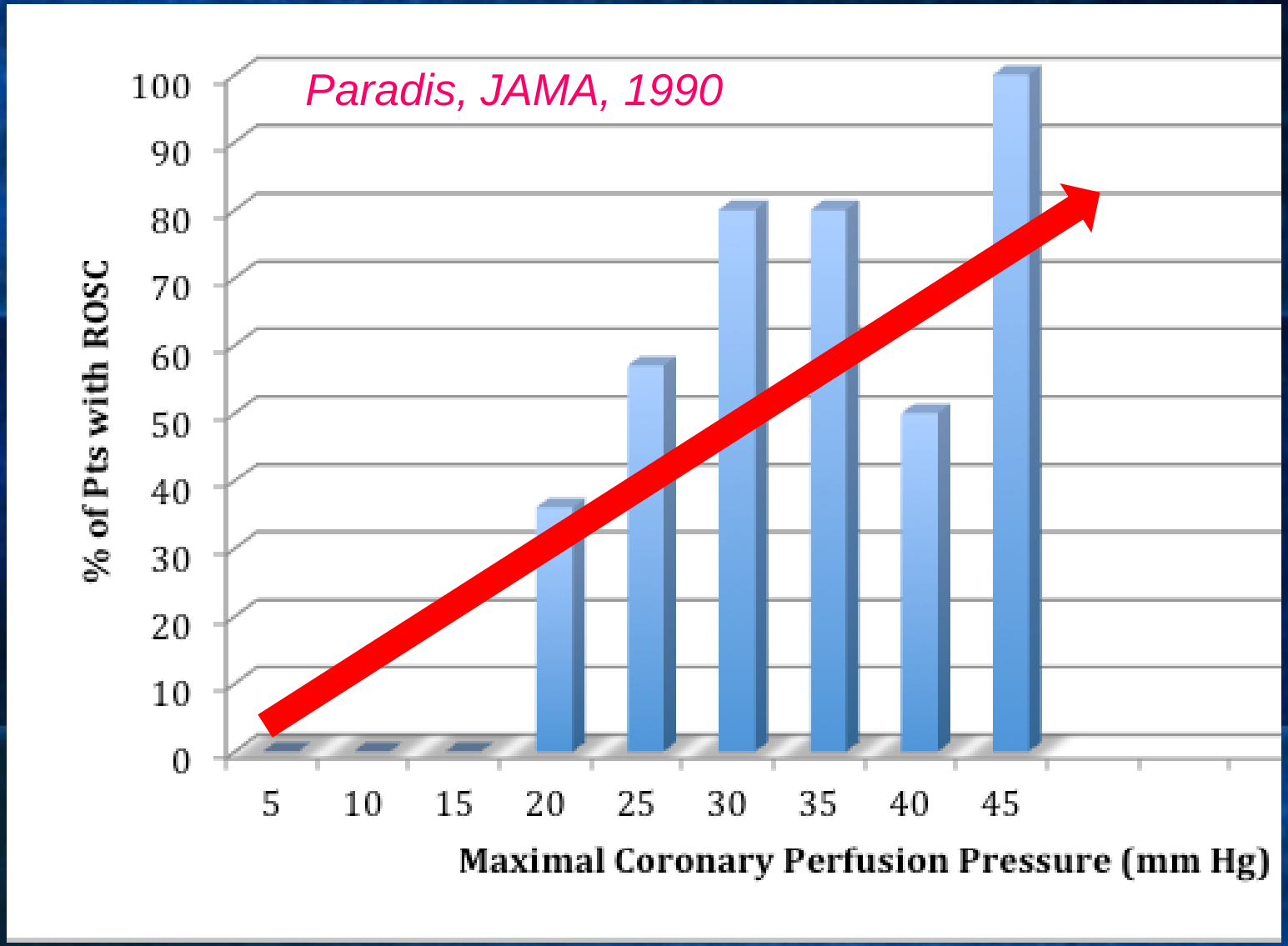
The critical effect of chest compressions is generation of coronary artery perfusion pressure (CPP)



CPP is the surrogate (animal studies) for ROSC



- Only patients (total n=100) with max. CPP of > 15 mm Hg had ROSC
- Likelihood of ROSC increased as CPP increased

AHA Consensus Statement

Cardiopulmonary Resuscitation Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital

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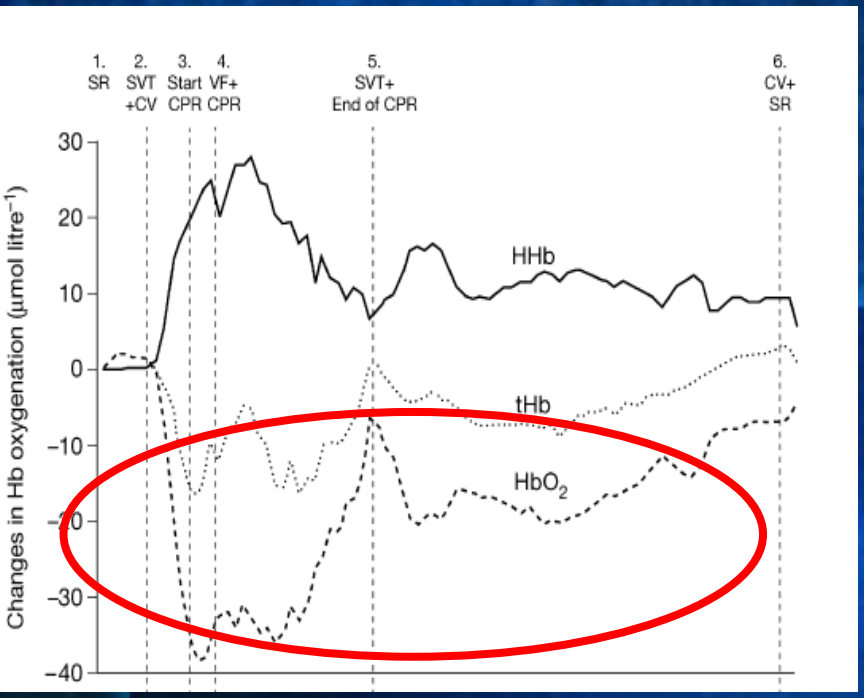
Meaney et al, Circulation, 2013

Monitoring Physiological Response to Resuscitation (Adults)

1. Invasive Monitoring: CPP >20 mm Hg
2. Arterial Line Only: BPd>25 mm Hg
3. Capnography Only: EtC02 >20 mm Hg

Organ Perfusion Monitoring During CPR

NIRS



Nagdyman, BJA, 2003

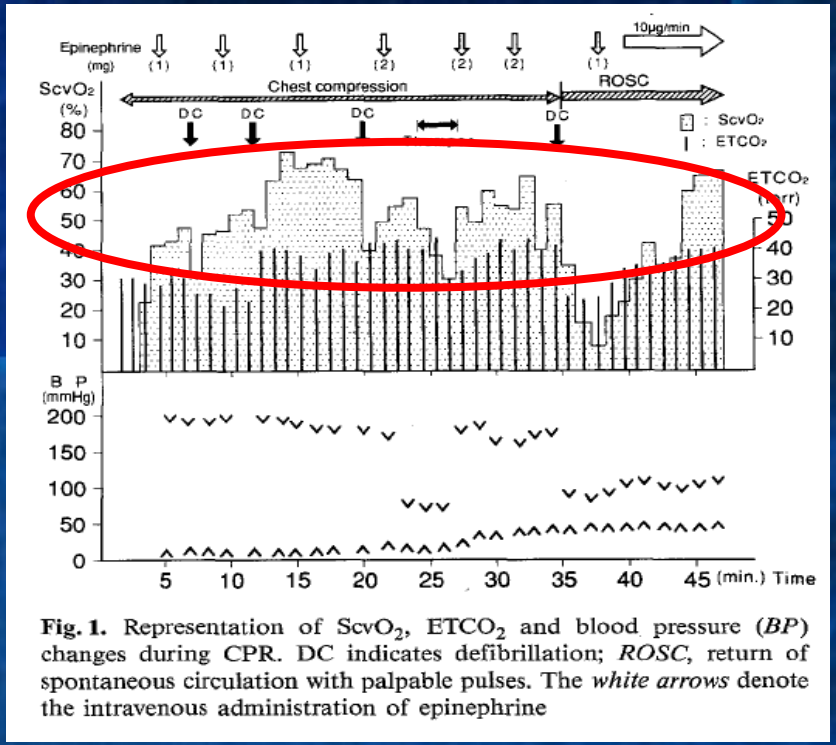
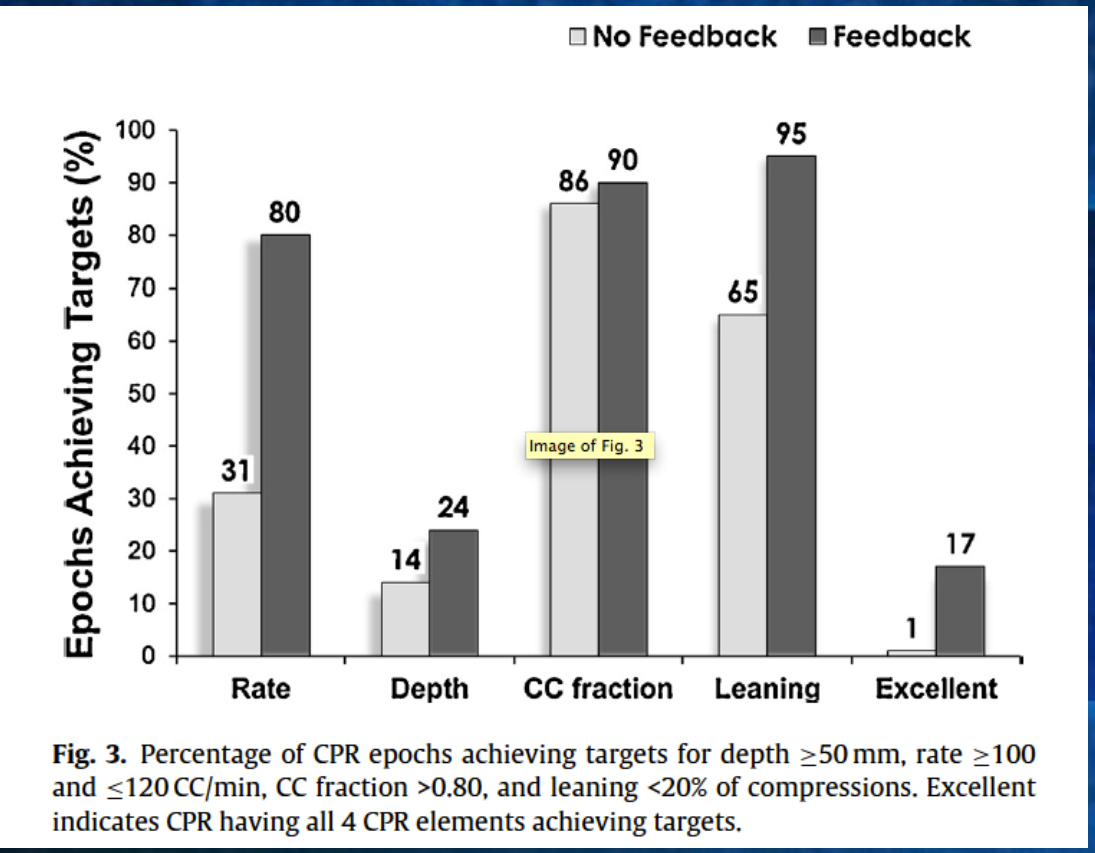


Fig. 1. Representation of $ScvO_2$, $ETCO_2$ and blood pressure (*BP*) changes during CPR. DC indicates defibrillation; *ROSC*, return of spontaneous circulation with palpable pulses. The *white arrows* denote the intravenous administration of epinephrine

Venous Oxygen Saturation Monitoring

Nakazawa, ICM, 1994

Real-time Feedback Improving Pediatric CPR Quality



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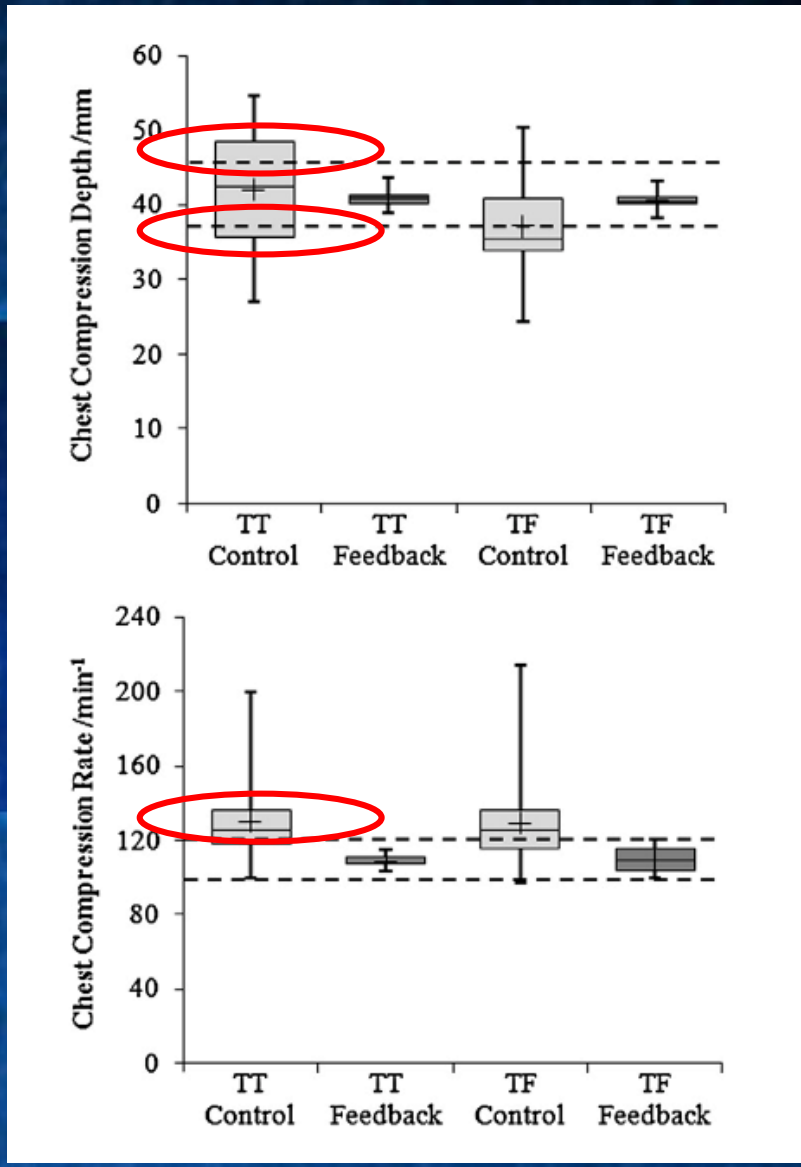
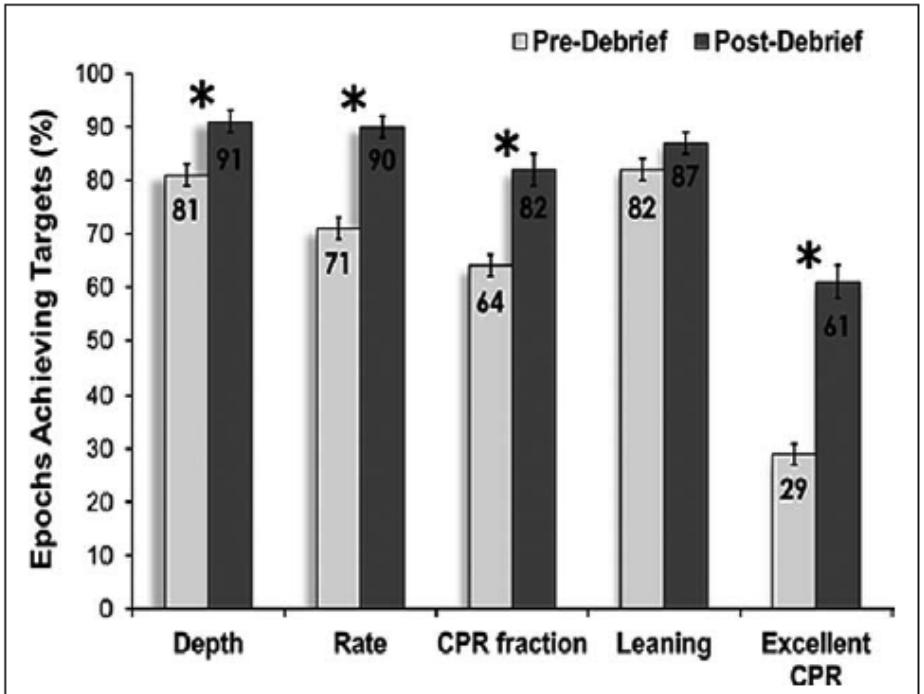
Sutton, Resuscitation, 2013

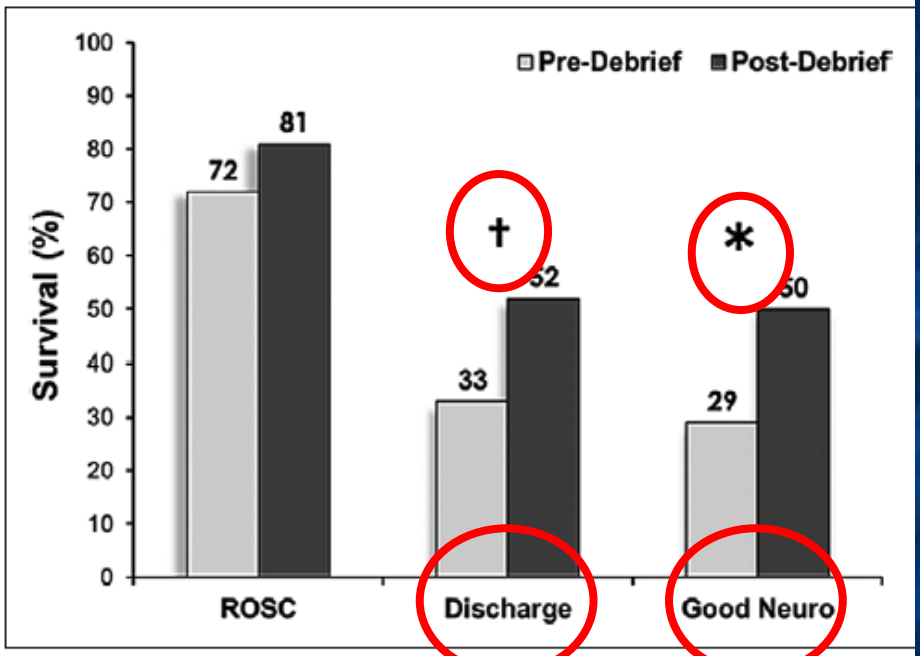


Martin, Resuscitation, 2013

Interdisciplinary ICU Cardiac Arrest Debriefing Improves Survival Outcomes

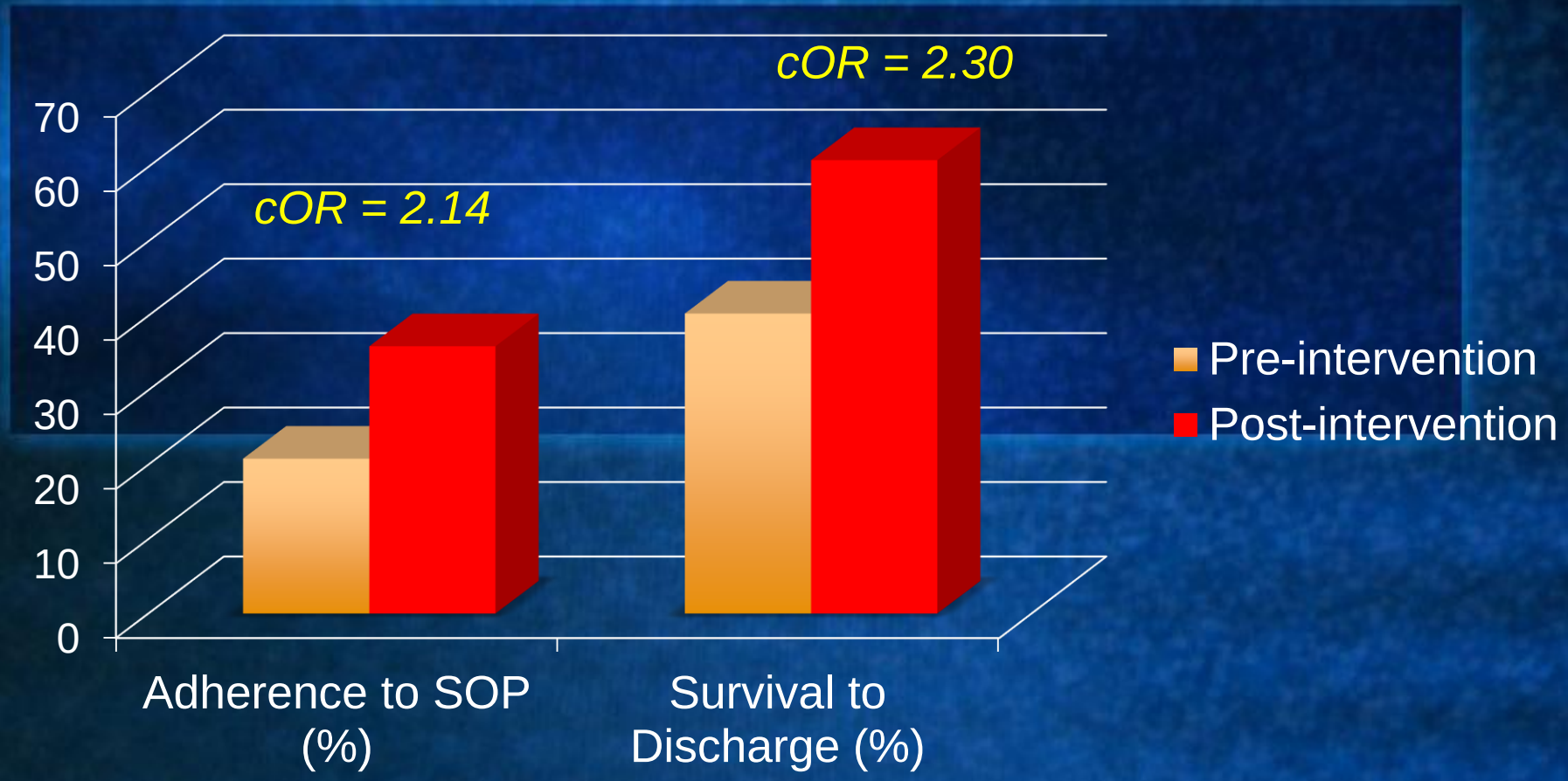
Wolfe, CCM, 2014





Improving Code Team Performance and Survival Outcomes: Implementation of Pediatric Resuscitation Team Training

Knight, CCM, 2014



Australian Resuscitation Council

ILCOR Systematic Reviews at
https://volunteer.heart.org/apps/pico/Pages/default.aspx

October 2015: ILCOR CoSTR and Council-Guidelines

Thank you for your attention

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