Beyond the Acronyms: Quality Pediatric Resuscitation

Maria J. Mandt, MD
Professor of Pediatrics
Medical Director of CCT & EMS

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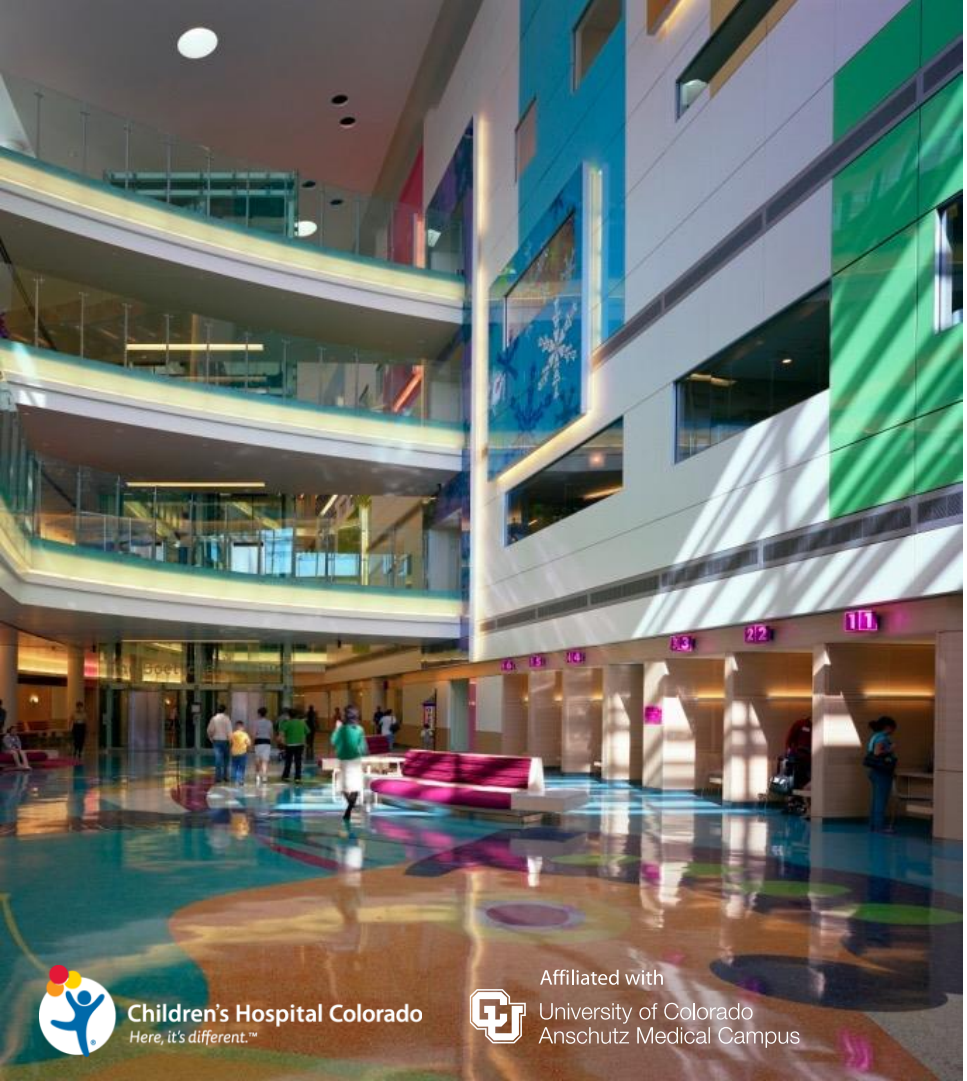

Financial Disclosure: I have no relevant financial disclosures with any commercial interest

Disclosure of Aspiration: Quality is not an act. It is a habit.

- Aristotle

Objectives

- CPR vs quality CPR: common errors and strategies to mitigate
- Let's talk about the WHY
- Previous PALS changes #hotmess?

Photo Credit: bartsblackboard.com

This Scene Plays Out Every 75 Minutes

EMS is called to the scene of a 3-month-old female found down in her crib by mother. CPR in progress by PD

Most common initial thoughts upon hearing this:

- Heart-wrenching
- This will be futile
- Bleak outcome
- Ugh . . . Why do I do this job?
- Hopelessness
- Performance anxiety

Prehospital Data

- >23,000 pediatric out-of-hospital cardiac arrests each year
- Bad news: overall ~10% of out-of-hospital pediatric arrests survive to hospital discharge
  - Most have permanent neurologic deficits

Despite all of the science and expensive toys, survival rate has been stagnant for 25 years

Can anything change this?

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Okubo M. et al, *Resuscitation* 2020; Fink EL et al. *Resuscitation* 2016

There Is Hope

- In-hospital cardiac arrest survival HAS improved
  - ROSC: 39% → 77%
  - Survival to discharge: 24% → 41%
  - Favorable neurologic outcome → 47% of survivors to discharge
- Attributed to:
  - Emphasis on **high-quality CPR**
  - Code teams and robust debriefing programs
  - Advances in post-resuscitation care

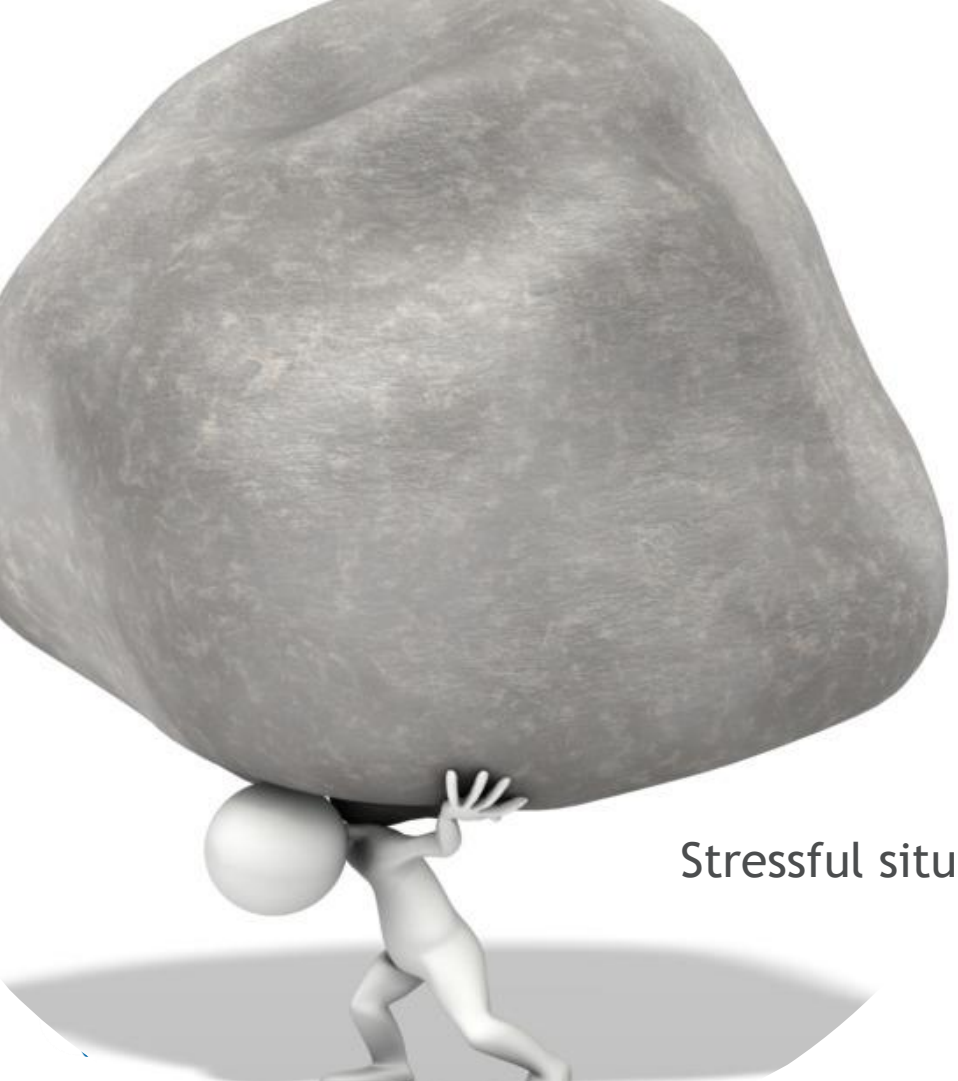
Topjian, AA. et al, *Circulation* 2020

Whoa, whoa, whoa

- IHCA survival is still < 50%! Can't we do better than that?
- Why haven't we seen such improvement on the prehospital side?
- Why does the AHA seem to recommend the same thing every year?

What If I Told You. . .

Photo Credit: memegenerator.com



Start with This:

The cognitive load in a pediatric resuscitation is HUGE

What does that mean?

Stressful situation + Infrequent occurrence = ⇧ Errors

Hansen M. et al. *JAMA Netw Open* 2023

Priorities and Game Plan

Hallmarks of a successful resuscitation:

1. Agency/Facility emphasis on frequent practice
2. Pre-patient planning and role assignment
3. Concentrate on the basics: Quality CPR
4. Remember the algorithm
5. Acknowledge the secondary provider trauma
6. Debrief

Before

During

After

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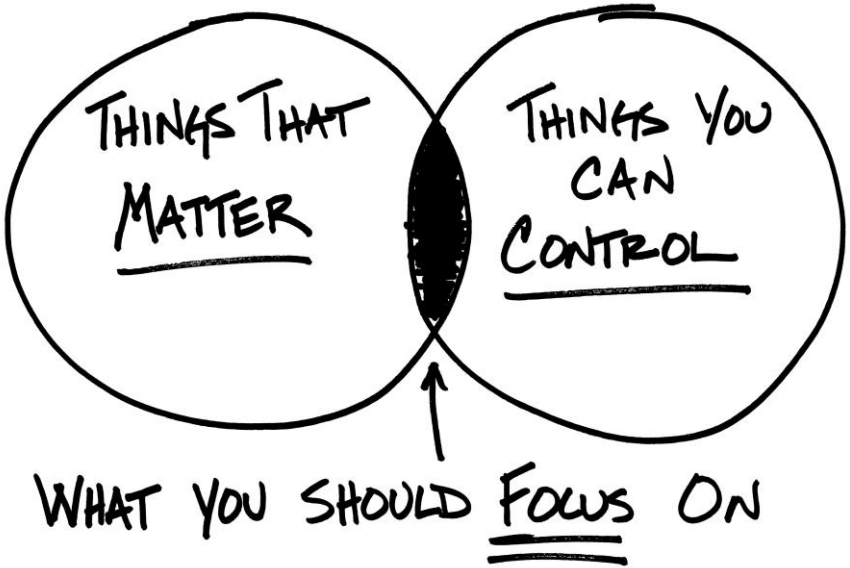
Remember the Mission



What Matters: ROSC and Neuro-intact Survival

Your focus:

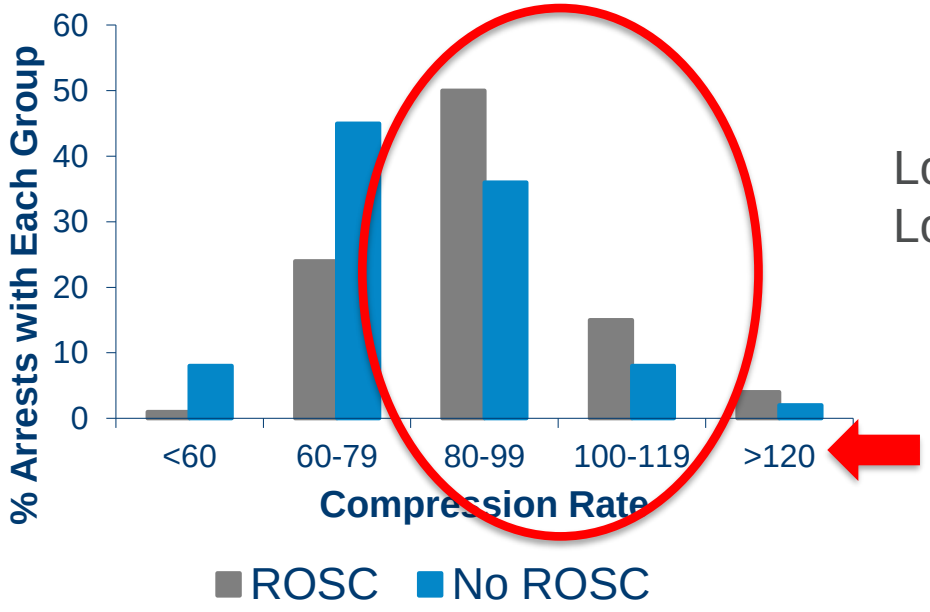
1. Quality CPR
2. Adequate oxygenation and ventilation
3. Algorithmic care/early epi

Concentrate on the Basics

Perform Quality CPR

- Push hard, push fast
- Minimize interruptions
- Allow full chest recoil
- Don’t hyperventilate

Push Hard, Push Fast: Why it Matters



Low compression **rate** =
Low ROSC rate

Fewer compressions
reaching target depth

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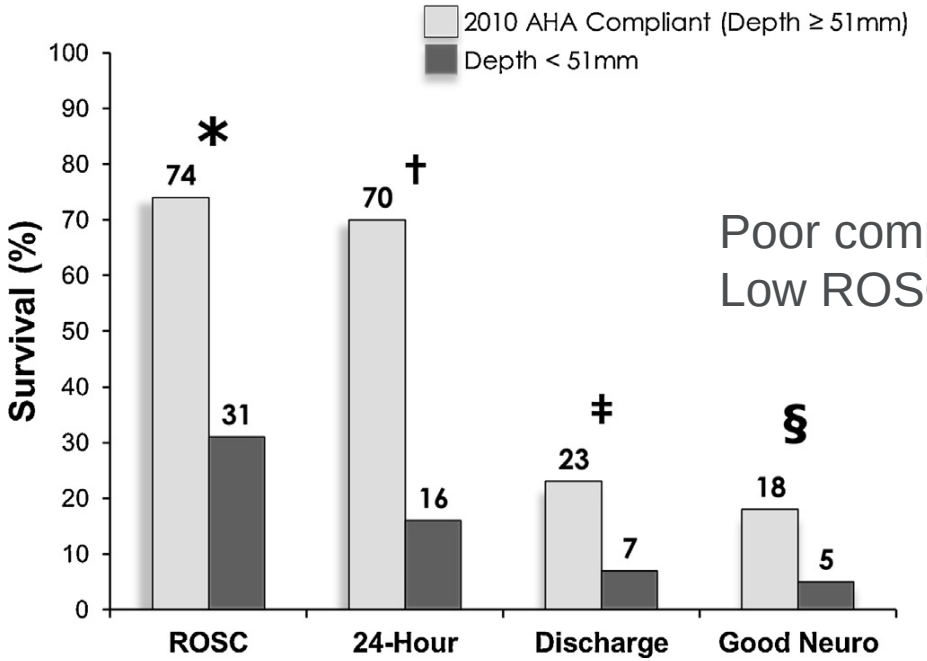
Abella BS et al. *Circulation* 2005

Push Hard, Push Fast: Why it Matters



Poor compression **depth** = Low ROSC rate

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Sutton RM et al. *Resuscitation* 2014

Push Hard, Push Fast: How Are We Doing?

- Inadequate compression depth and rate very common across all healthcare providers

239 cardiac arrest resuscitations across 18 hospitals:

- CPR compliance (rate/depth/CCF) low and impacted by age
- Primary player: universally poor chest compression depth

Esangbedo I et al. *Resuscitation* 2020

Strategy for Improvement: Technique

Improve your consistency:

- 2-thumb technique in infants regardless of # of rescuers
  - 5.6mm increased depth
  - 37% more compressions in range
  - Doesn't impede ventilations
- 1 or 2 hand technique in children

Jiang J, et al. Am *J Emerg Med* 2015; Millin MG et al. *Resuscitation* 2020;
Photo credit: rrapid.leeds.ac.uk; Smereka et al.

Strategy for Improvement: Feedback Devices

Increasing number of studies:

- ✓ Most significant gains in rate and depth
  - Rate achieved with device: 67%, without: 27%
  - Depth achieved with device: 27%, without: 12%
- ✓ May delay evidence of fatigue
- ✓ Doesn't seem to help chest recoil or pauses
- ✓ May be correlated with increased survival

Response from the Acronyms:

Photo credit: www.emojimovie.fandom.com

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Cheng, A et al. *JAMA Pediatr* 2015; Lakomek F et al. *PLoS One* 2020; Buleon C et al. *Am J Emerg Med* 2016; Leo WZ et al. *Sci Rep* 2023; Taylor S et al. *Prehosp Emerg Med* 2021

Strategy for Improvement: Focus on the BP

Invasive Blood Pressure Monitoring to Assess CPR Quality

2020 (Updated): For patients with continuous invasive arterial blood pressure monitoring in place at the time of cardiac arrest, it is reasonable for providers to use diastolic blood pressure to assess CPR quality.

Hemodynamic CPR likely works!

Help from the BPs:

- Improved survival when DBP > 25mmHg (infants) DBP > 30mmHg (kids)
- Pediatric ICU: higher SBP associated with higher survival to discharge

Topjian AA, et al. *Circulation* 2020; Sutton RM et al. *Resuscitation* 2019

So Where Does That Leave the Frontline??

Photo credit: learningadvacedenglish.blogspot.com

Strategy for Improvement: $EtCO_2$

Increasing number of studies. . . But,

> 2. $ETCO_2$ monitoring may be considered to assess the quality of chest compressions, but specific values to guide therapy have not been established in children.[7,8]

Response from the Acronyms:

The trouble with $EtCO_2$ for CPR quality:

- Impacted by more than just circulation
- No target EtCO2 values known for qCPR
- No outcome data

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Photo credit: www.emojimovie.fandom.com

Lakomek F et al. *PLoS One* 2020; Buleon C et al. *Am J Emerg Med* 2016

The Capnography Conundrum

Multicenter prospective observational study of 234 kids < 18 years

- All were intubated and had arterial lines prior to their arrest

Outcome Highlights

EtCO2>= 20 was associated with:

1. Better outcomes
2. Higher intra-arrest blood pressures
3. Correct CPR ventilation rate!

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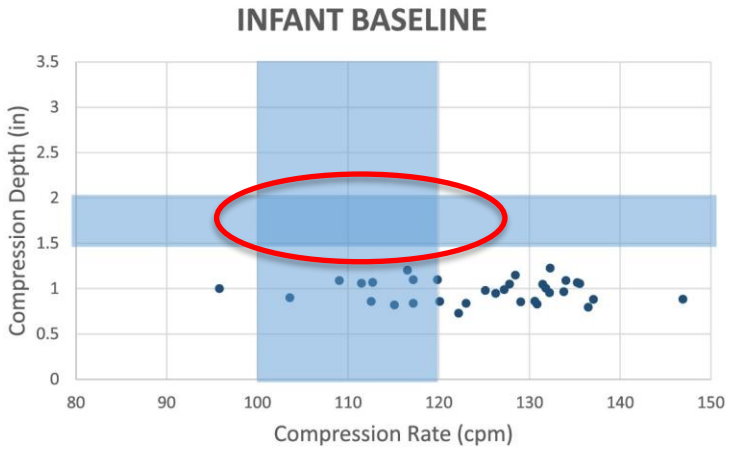
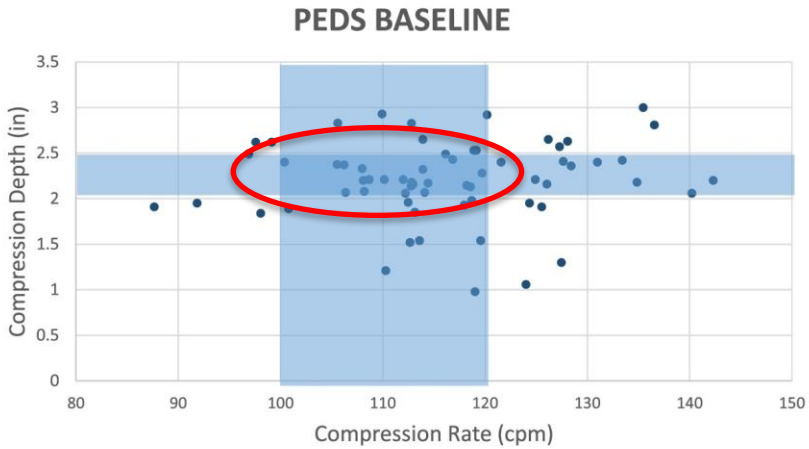
Morgan RW et al. *Circulation* 2024

Strategy for Improvement: Practice Makes Perfect?

Standard CPR training in a children's hospital:





2 of 10 achieved ROSC

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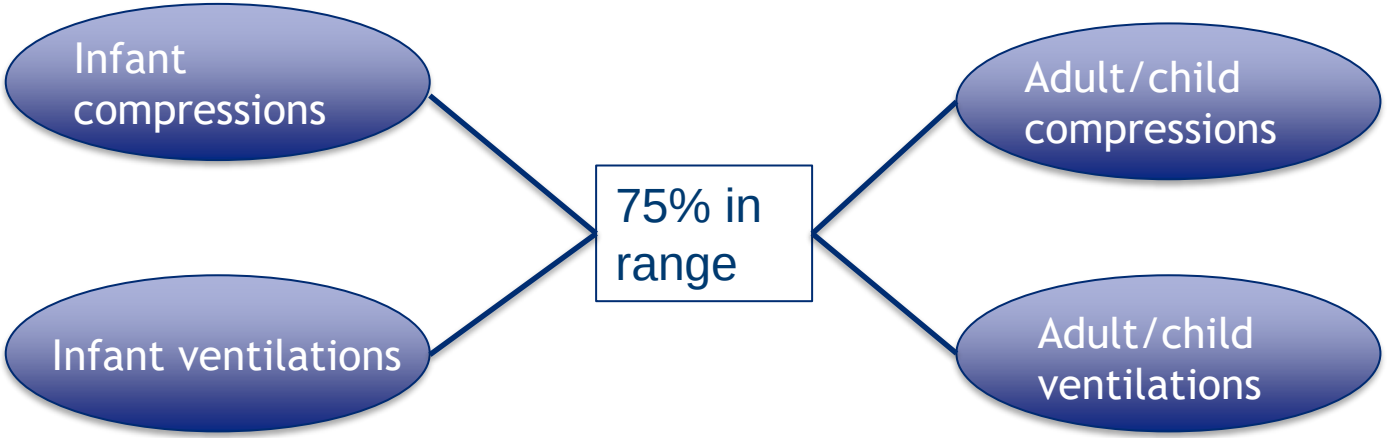
Donoghue A et al. *Resuscitation Plus* 2021

Strategy for Improvement: Practice Makes Perfect?

High-frequency CPR training implemented: quarterly skills training



11 of 28 (39%) achieved ROSC

Donoghue A et al. *Resuscitation Plus* 2021

Strategy: Deliberate Practice

Learners should be given:

- A discrete goal to achieve
- Immediate feedback on their performance
- Ample time for repetition to improve

Circulation

Part 6: Resuscitation Education Science

2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

TOP 10 TAKE-HOME MESSAGES

1. Effective education is an essential contributor to improved survival outcomes from cardiac arrest.
2. Use of a deliberate practice and mastery learning model during resuscitation training improves skill acquisition and retention for many critical tasks.
3. The addition of booster training to resuscitation courses is associated with improved cardiopulmonary resuscitation (CPR) skill retention over time and improved neonatal outcomes.
4. Implementation of a spaced learning approach for resuscitation training improves clinical performance and technical skills compared with massed learning.
5. The use of CPR feedback devices during resuscitation training promotes CPR skill acquisition and retention.
6. Teamwork and leadership training, high-fidelity manikins, in situ training, gamified learning, and virtual reality represent opportunities to enhance resuscitation training that may improve learning outcomes.
7. Self-directed CPR training represents a reasonable alternative to instructor-led CPR training for lay rescuers.

Adam Cheng, MD, Chair
David J. Magid, MD, MPH
Marc Auerbach, MD, MSCE
Farhan Bhanji, MD, MEd
Blair L. Bigham, MD, MSc
Audrey L. Blewer, PhD, MPH
Katie N. Dainty, MSc, PhD
Emily Diederich, MD, MS
Yiqun Lin, MD, MHSc, PhD
Marion Leary, RN, MSN, MPH
Melissa Mahgoub, PhD
Mary E. Mancini, RN, PhD
Kenneth Navarro, PhD(c)
Aaron Donoghue, MD, MSCE, Vice Chair

Cheng A. et al. *Circulation* 2020; Donoghue A. et al. *Resusc Plus* 2021

Concentrate on the Basics

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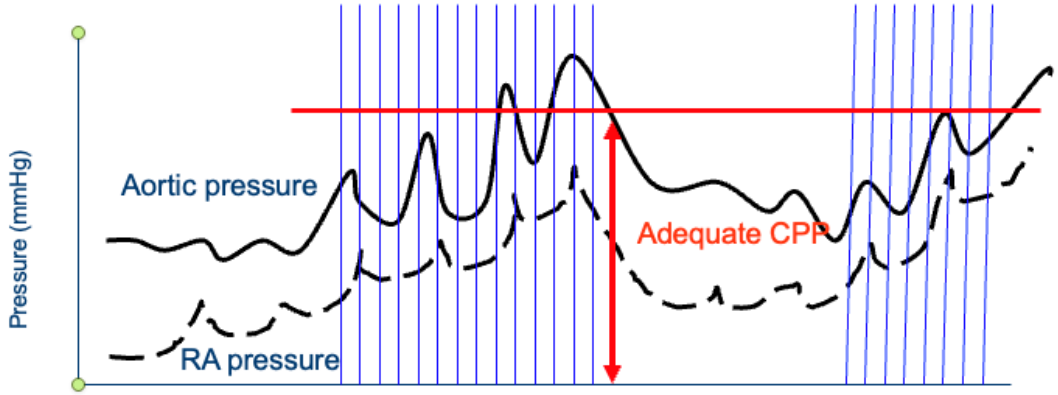
Minimize Interruptions: Why It Matters

Pauses result in prolonged duration of low CPP

Number or Length?

- Every 5 second interval increase in compression pause = 3% ↓ in survival!



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Lauridsen KG A et al. *Circulation* 2024

Minimize Interruptions: How Are We Doing?

Prolonged interruptions in chest compressions are common

- Pediatric CPR in a tertiary care ED
  - 178 total minutes of interruption in 650 minutes of CPR = 73% CCF
  - 58/178 (33%) of interruptions lasted > 10 seconds
- Multi-center prospective trial of simulated pediatric cardiac arrests
  - 19% of pauses lasted >10 seconds
  - Median of 10 pauses per scenario

Good communication was the only thing that improved pause duration

Donoghue A et al. *Resuscitation* 2015; Kessler DO et al. *Pediatr Crit Care Med* 2017

Strategy for Improvement: Prepare

Fingers ready?

- Single site chosen? Make it a pumper

Hands-off leader?

- Clear expectations, decisive

Does this address the biggest cause for pause?

Photo credit: simulead.com

O'Connell KJ et al. *Resuscitation* 2019

Minimize Interruptions: How Are We Doing?

Year over year, what causes the longest pause?

Video review of pediatric cardiac arrests:

- 62% of pulse checks too long
- 65% of rhythm checks lasted too long
- 53% of intubation attempts lasted too long and **caused longest pauses**

51 patients had intubation attempt with 84 total attempts
Median pause time 18s per attempt

O'Connell KJ et al. *Resuscitation* 2019; Jones SI et al. *Pediatr Crit Care Med* 2020

Strategies for Improvement: Proposed

Strategy for Improvement:

- Intubate during compressions
- Intubate during compression pause
- Intubate with video laryngoscopy

Concerns:

- Very little prospective pediatric data
- Lower first-pass success (VL or DL)
- If you are concentrating on intubation, you're not concentrating on CPR quality

Or

Donoghue A et al. *Resuscitation* 2016; Okamoto H, et al. *Resuscitation* 2019; Rodriguez-Nunez A, et al. *Eur J Pediatr* 2014

Strategies for Improvement: No Intubation at All?

- Choose a supraglottic device or BMV?

Intubation during pediatric in-hospital cardiac arrest:

- Survival to hospital discharge lower in the ETI group
- No difference in ROSC or favorable neurologic outcome between intubated and not

CARES registry: 1794 pediatric prehospital cardiac arrests across >400 EMS agencies

	Modality %	% Survival
BVM only	45%	14.1%
ETI	42%	7.0%
SGA	12.5%	10.2%

BMV associated with double the rate of survival to discharge!

Andersen LW et al. *JAMA* 2016; Hansen ML et al. *Resuscitation* 2017

Field Advanced Airway Management During Arrest: Essential or Detrimental?

Bottom Line: No strong evidence to support ETI over BVM/SGA for most situations

Mounting evidence of detrimental effects in pediatric cardiac arrest:

- AA placement during CPR associated with worse outcomes in multiple studies
- Inadvertent hyperventilation and excessive pressures after intubation
- Delays fluid and epi administration due to provider distraction
- Requires significant investment to attain and maintain skill and safety
- Little evidence that it improves outcomes

May be a time and place for intubation, but it probably isn't ***during*** an arrest

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Harris M et al. *Prehosp Emerg Care* 2022; Pepe PE et al. *Crit Care* 2015; Aufderheide TP, et al. *Circulation* 2004; Niebauer et al. *Pediatrics* 2011; Mandt M et al. *Prehosp Emerg Care* 2022

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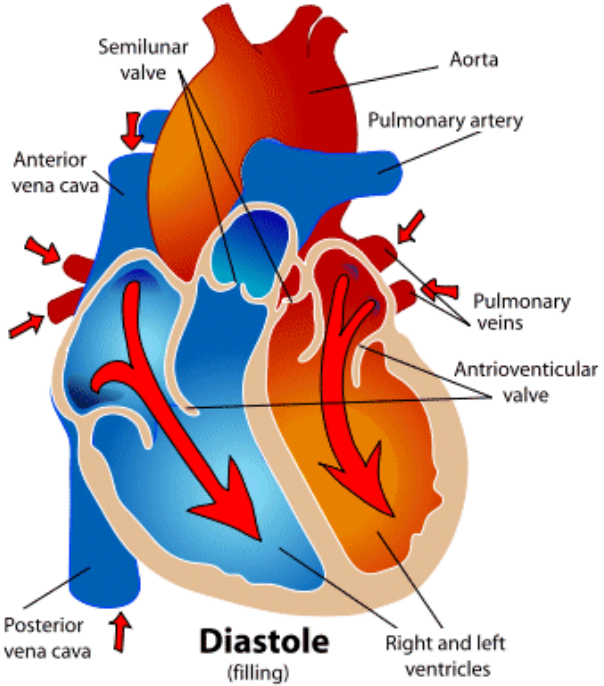
Allow Full Chest Recoil



- Recoil = Diastolic phase
- Diastolic phase = heart perfusion and preload phase

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Photo credit: wellnessadvocate.com

Full Chest Recoil: Why It Matters

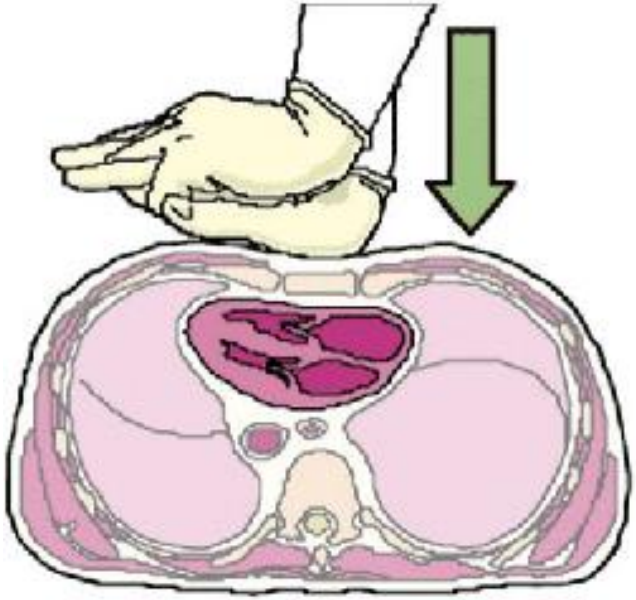

Photo credit: JEMS.com

Incomplete chest recoil associated with:

- Higher residual intrathoracic pressures
- Significantly reduced coronary perfusion, blood flow and cerebral perfusion

Seen ~25% of the total time of arrest!

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Yannopoulos D, et al. *Resuscitation* 2005; Zuercher M, et al. *Crit Care Med* 2010

Full Chest Recoil: Strategies for Improvement

- Avoid rescuer fatigue
- Use a step stool
- CPR feedback devices show most promise
- +/- lift heel of hand slightly, leaving rest of hand in place

Photo credit: slideshare.com; Lapsansky

Aufderheide TP et al. *Resuscitation* 2005; Kim CW et al. *Prehosp Disaster Med* 2020

Concentrate on the Basics

Perform Quality CPR

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Photo credit: gagadaily.com

Avoid Hyperventilation

What is the appropriate ventilation rate for pediatric resuscitations?

Previously: Respiratory failure 1 breath q3-5 seconds (12-20/min)

Cardiopulmonary failure: 1 breath q6-8 sec (8-10/min)

BIG CHANGE made by the AHA in 2020:

You May Recall. . .

Major New and Updated Recommendations

Changes to the Assisted Ventilation Rate: Rescue Breathing

2020 (Updated): (PBLS) For infants and children with a pulse but absent or inadequate respiratory effort, it is reasonable to give 1 breath every 2 to 3 seconds (20-30 breaths/min).

Now Same Rate

Changes to the Assisted Ventilation Rate: Ventilation Rate During CPR With an Advanced Airway

2020 (Updated): (PALS) When performing CPR in infants and children with an advanced airway, it may be reasonable to target a respiratory rate range of 1 breath every 2 to 3 seconds (20-30/min), accounting for age and clinical condition. Rates exceeding these recommendations may compromise hemodynamics.

Topjian AA, et al. *Circulation* 2020

Hyperventilation is STILL BAD!

Why do we worry about hyperventilation?

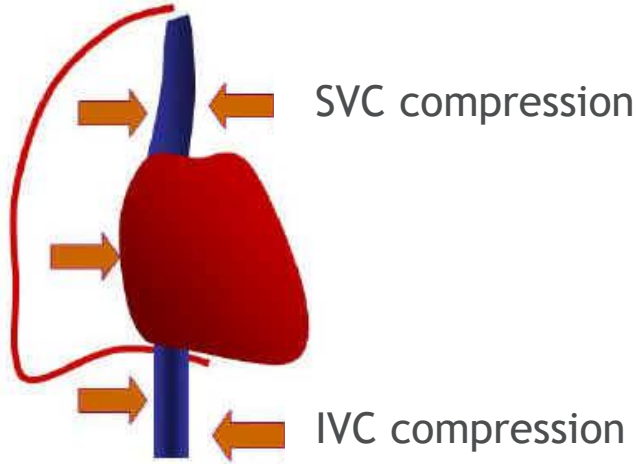

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Photo credit: bronchus technologies

What Brought This About?

Multicenter cohort study of 52 pediatric cardiac arrest events in PICUs/CICUs

- First documented rhythm:
  - Asystole/PEA in 17%
  - VF/VT in 9%
  - Bradycardia with poor perfusion 74%

Photo credit: psychologytoday.com

After some data crunching:

- NO patient received ventilation rate within AHA guidelines

Sutton RM, et al. *Crit Care Med* 2019

What Brought This About?

But then . . .

1. Ventilation rates (≥ 30 in infants and ≥ 25 in children) were common and associated with a 5-fold increase in survival to discharge
2. RR higher than than 35 bpm associated with decrease in SBP

Maybe applying adult rates to children isn't the best idea?

Photo credit: tenor.com

Sutton RM, et al. *Crit Care Med* 2019

Acronym Response to This Data:

International Liaison Committee on Resuscitation (ILCOR):

- No change

European Resuscitation Council (ERC):

- Different rates for different ages

Resuscitation Council of Asia (RCA):

- Adoption of rates is different in different countries

Ong GY, et al. *Resusc Plus* 2023

PALS Response

- These decades-old recommendations were based on data extrapolated from animals and adults and implemented for ease of education.
- There is no data showing lower rates to be beneficial in children.
- With lower rates, we were hyperventilating 100% of the time. It's still bad. We still need to slow down.

Bottom Line:

- Agency/Department-level protocols should be followed
- Opinions are passionate
- Further clarity expected in the coming years

Hyperventilation: Strategies for Improvement

- Use 2-person BMV technique when possible
- 1-finger technique
- Count aloud, metronome or ventilation timer
- Watch capnograph
- Beware of the advanced airway

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Kroll M et al. *Prehosp Emerg Med* 2019; O'Connell KJ et al. *Resuscitation* 2023

Priorities and Game Plan

Hallmarks of a successful resuscitation:

1. Agency emphasis on frequent practice
2. Pre-arrival planning and role assignment
3. Concentrate on the basics: Quality CPR
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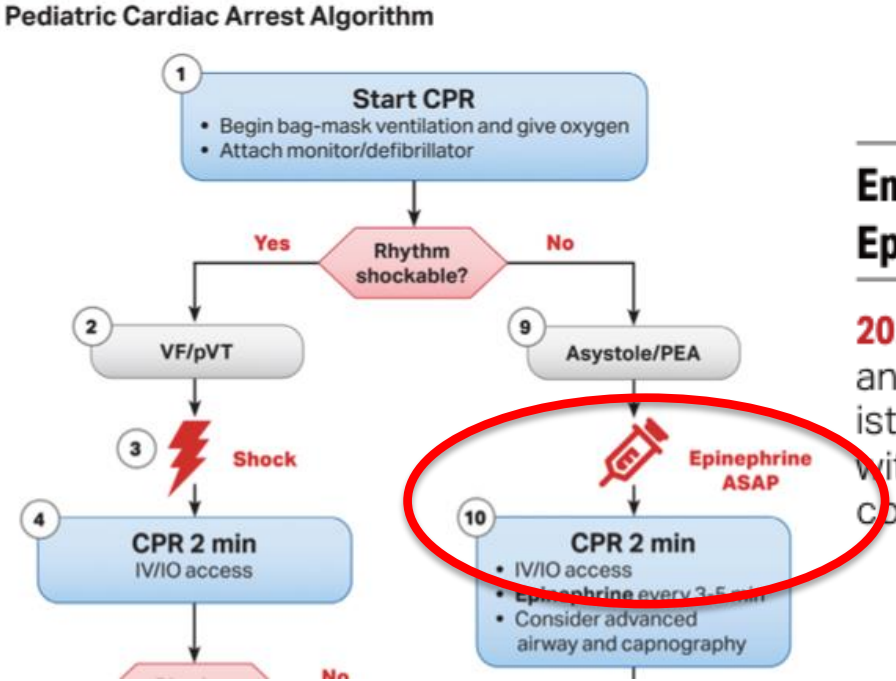
Remember the Algorithm



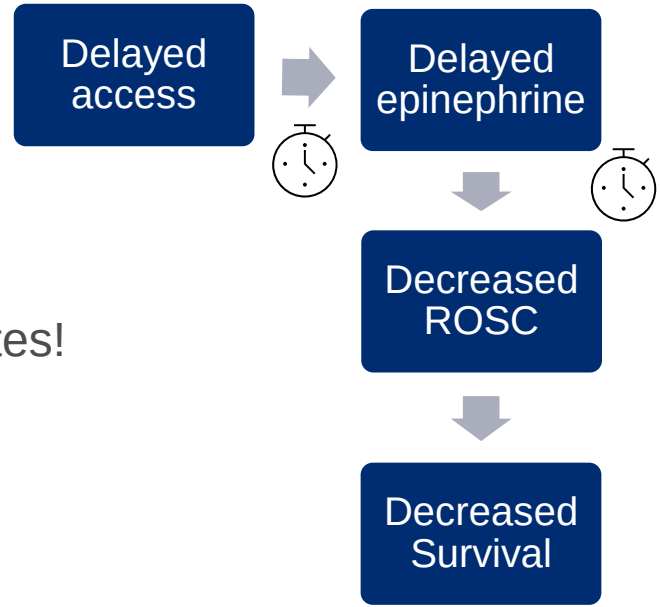
Emphasis on Early Epinephrine Administration

2020 (Updated): For pediatric patients in any setting, it is reasonable to administer the initial dose of epinephrine within 5 minutes from the start of chest compressions.

Topjian AA, et al. *Circulation* 2020

Get That Vascular Access!

- Common Pitfall: Delaying IO placement while looking for other access points delays epi



Mean time to drill: >3 minutes!

Lee SH, et al. *Ann Emerg Med* 2020; Hansen M et al. *Circulation* 2018

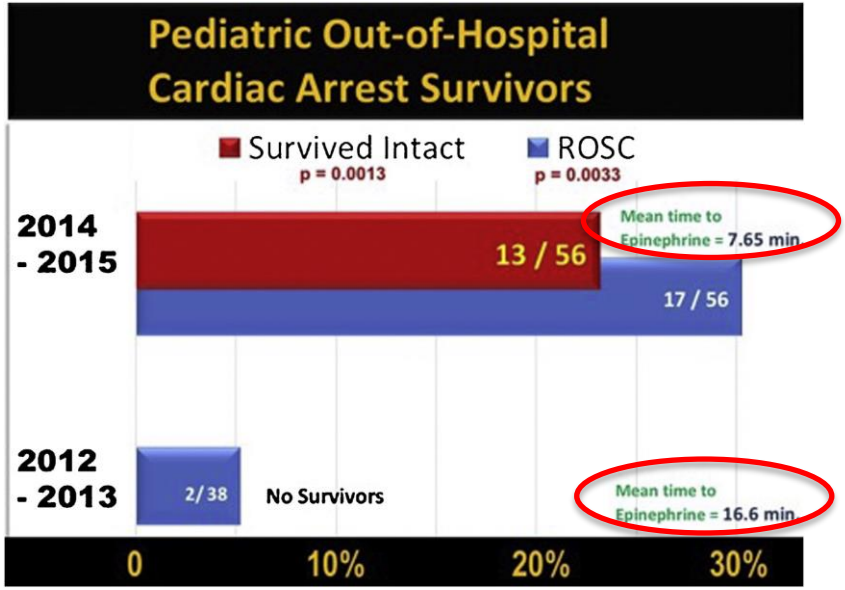
How Critical is Early Epi?

- Earlier is better
- “Sweet spot” time frame for initial dose OR interval frequency are unknown

PALS:

2. For pediatric patients in any setting, it is reasonable to administer the initial dose of epinephrine within 5 min from the start of chest compressions.[12–16]

3. For pediatric patients in any setting, it is reasonable to administer epinephrine every 3–5 min until ROSC is achieved.[17,18]



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Banerjee PR, et al. *Resuscitation* 2019; Andersen LW et al. *JAMA* 2015; Maconochie IK et al. *Circulation* 2020

Priorities and Game Plan

Hallmarks of a successful resuscitation:

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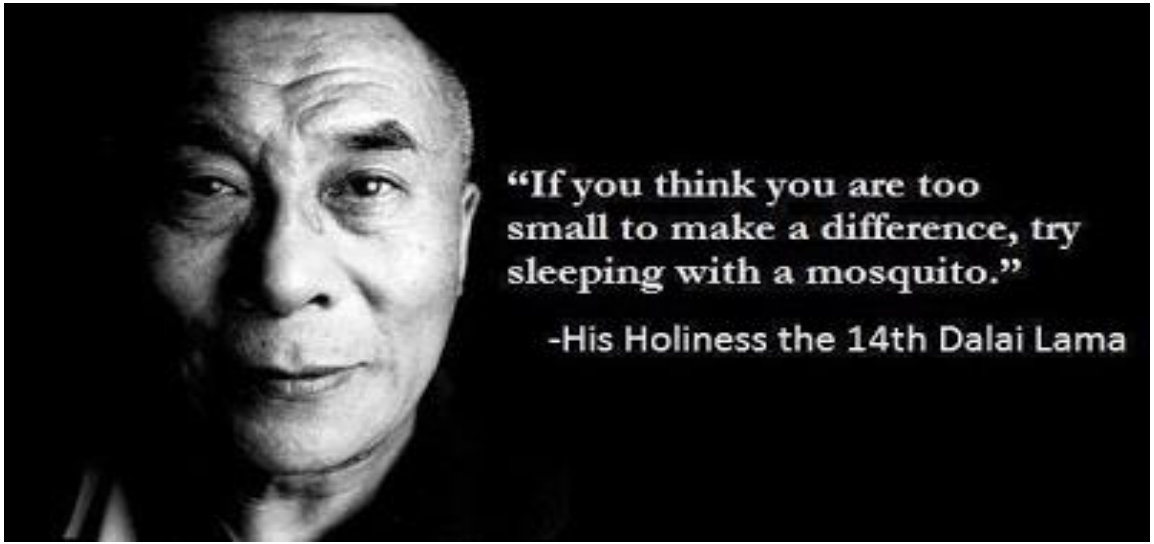
Also important!

Summary

- Pediatric cardiac arrest is a rare, stressful event. Preparation is your best strategy
- It's still about quality!
- I before E, and especially before A
- Pediatric ventilation rates for kids (?)
- Use all the tools in your toolbox

Photo credit: notsalmon.com

Thank You, Fellow Mosquitoes!



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