Pediatric Resuscitation and the Acronym War: Where Do We Go From Here?

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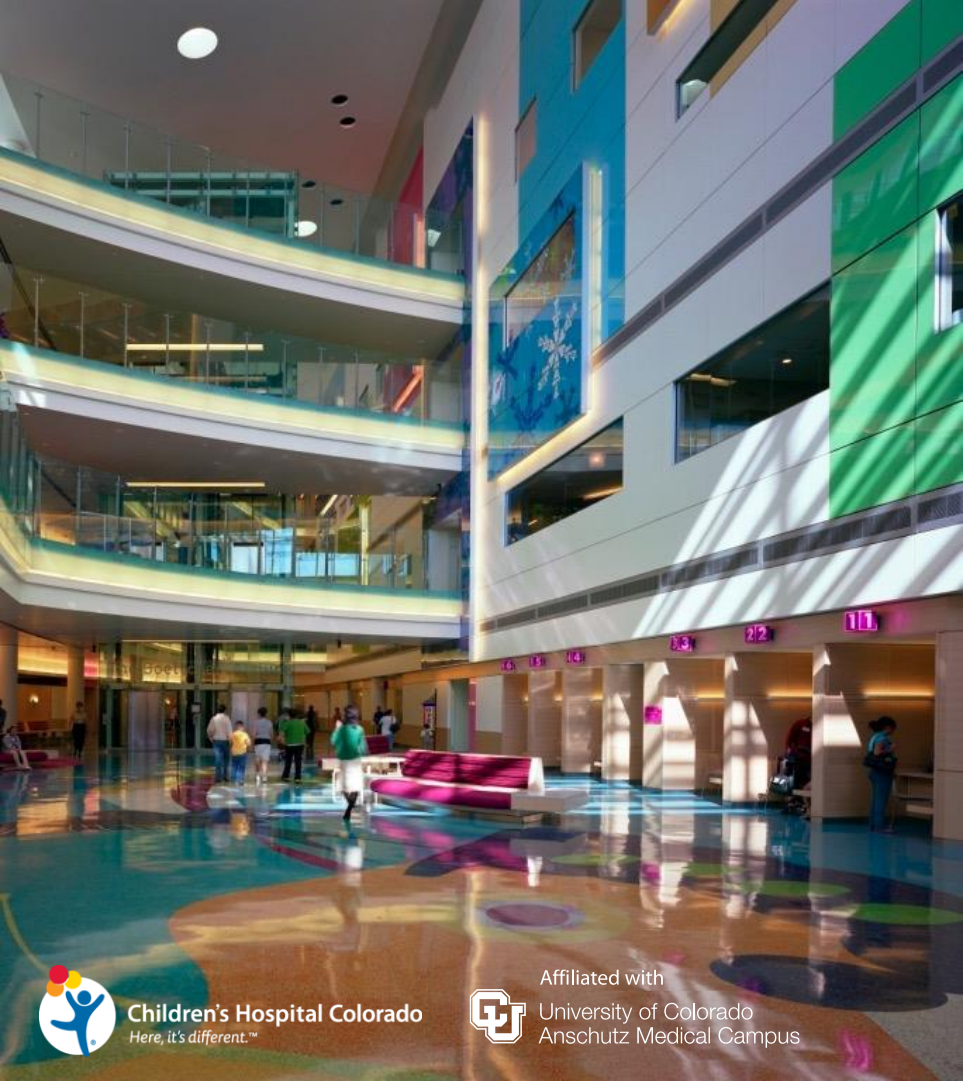

Financial Disclosure: I have no relevant financial disclosures with any commercial interest

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

- Aristotle

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
- Oh no . . . Why do I do this?
- Hopelessness
- Performance anxiety

Prehospital Data

- >7000 pediatric out-of-hospital cardiac arrests each year
- Bad news: overall 6-8% of out-of-hospital pediatric arrests survive to hospital discharge
  - Most have permanent neurologic deficits
  - Survival rate stagnant for 25 years

Can anything change this?

Fink EL. et al, *Resuscitation* 2016

There Is Hope

- In-hospital cardiac arrest survival HAS improved
  - ROSC: 39% → 77%
  - Survival to discharge: 24% → 43%
  - Prolonged CPR >35 minutes with 12% survival
- Attributed to:
  - Emphasis on **high-quality CPR**
  - Robust debriefing programs
  - Advances in post-resuscitation care

de Caen A. et al, *Circulation* 2015

Whoa, whoa, whoa

- IHCA is still < 50% survival! 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

Many Groups Working to Move the Mark

Photo Credit: cprblog.heart.org

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Objectives

- CPR vs quality CPR: common errors and strategies to mitigate
- PALS changes #hotmess?

Photo Credit: bartsblackboard.com

Priorities and Game Plan

Hallmarks of a successful resuscitation:

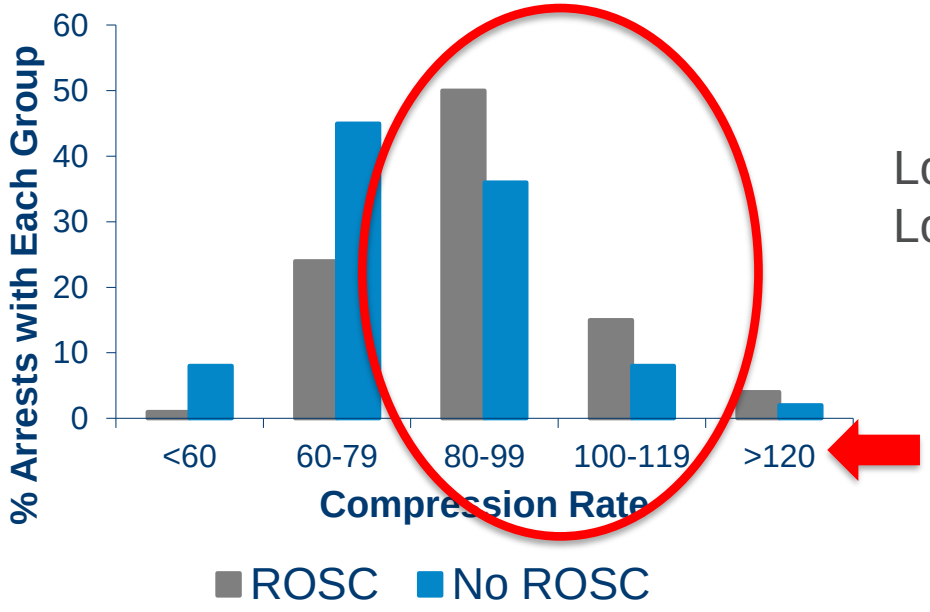
1. Agency/Facility emphasis on frequent practice
2. Pre-patient planning and role assignment
3. Concentrate on the basics: Quality CPR
4. Remember the algorithm
5. Acknowledge the secondary provider trauma
6. Debrief

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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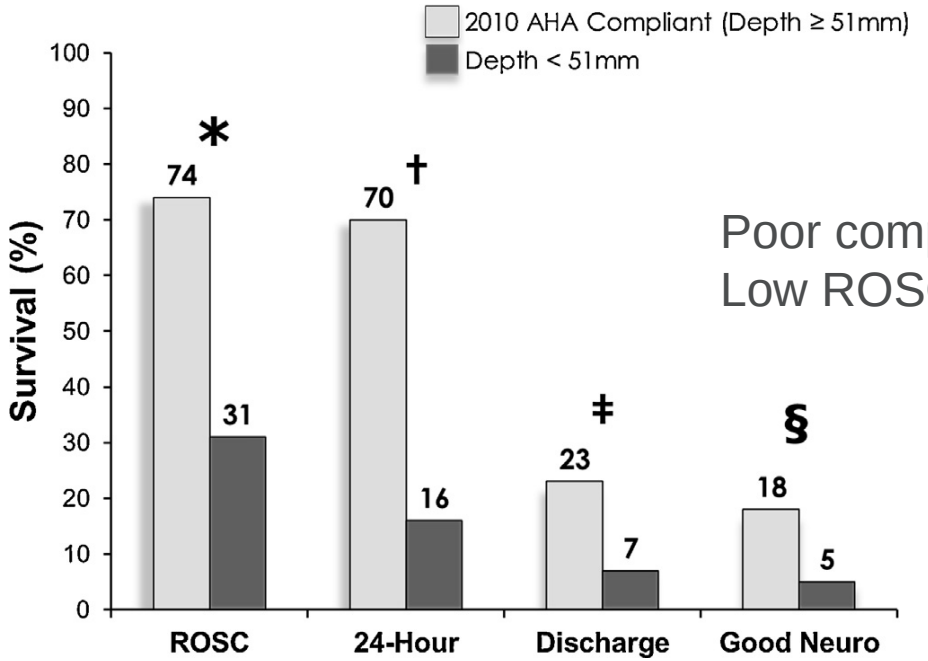
Abella BS et al. *Circulation* 2005

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%

✓ Variable improvement in recoil and pause reduction

✓ May delay evidence of fatigue

✓ May be correlated with increased survival

Response from the Acronyms:

Photo credit: www.emojimovie.fandom.com

Cheng, A et al. *JAMA Pediatr* 2015; Lakomek F et al. *PLoS One* 2020; Buleon C et al. *Am J Emerg Med* 2016

What's The Hang-up?

Photo credit: Zoll.com

Photo credit: MCR Medical

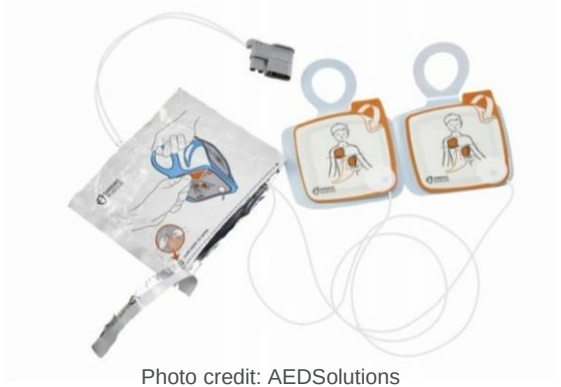

Photo credit: AEDSolutions

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Strategy for Improvement: DBP

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.

Help from the DBP

- Improved survival when
  DBP > 25mmHg (infants)
  DBP > 30mmHg (kids)

Topjian AA, et al. *Circulation* 2020

So Where Does That Leave EMS?

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]

The trouble with $EtCO_2$ for CPR quality:

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

Response from the Acronyms:

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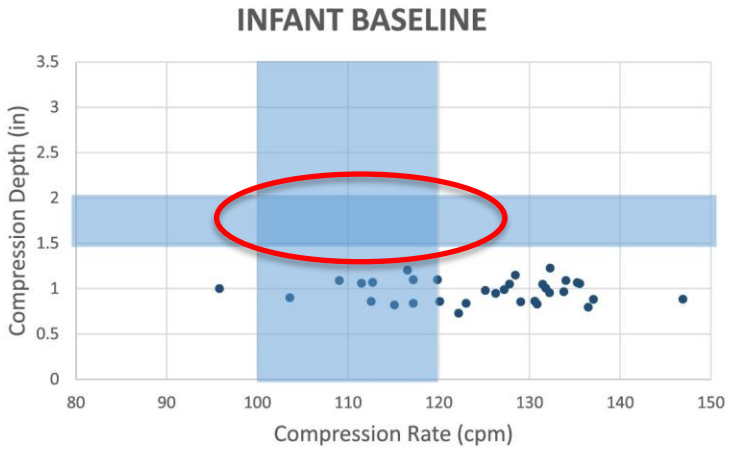
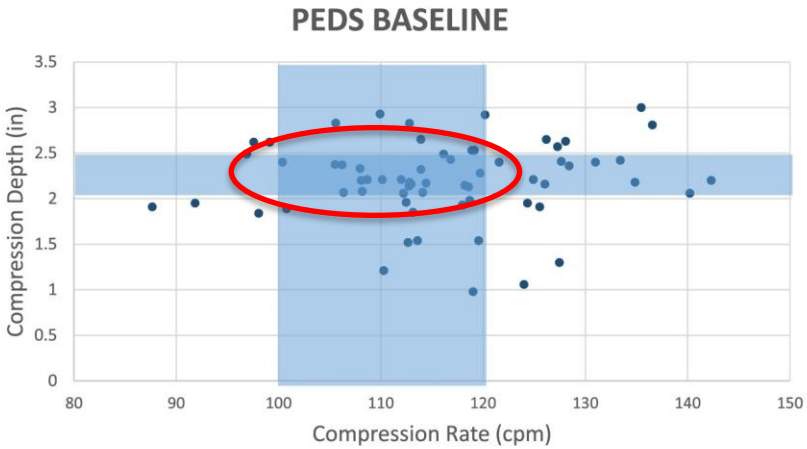
Cheng, A et al. *JAMA Pediatr* 2015; Lakomek F et al. *PLoS One* 2020; Buleon C et al. *Am J Emerg Med* 2016

Strategy for Improvement: Practice Makes Perfect?

Standard CPR training in a children's hospital:





2 of 10 achieved ROSC

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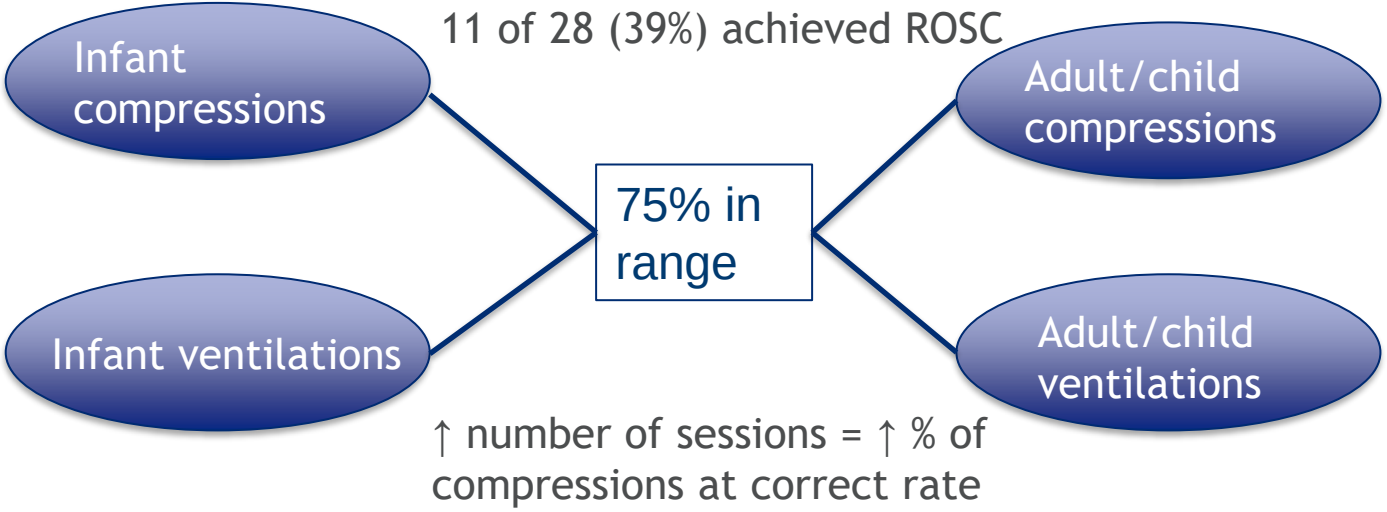
Donoghue A et al. *Resuscitation Plus* 2021

Strategy for Improvement: Practice Makes Perfect?

High-frequency CPR training implemented: quarterly skills training



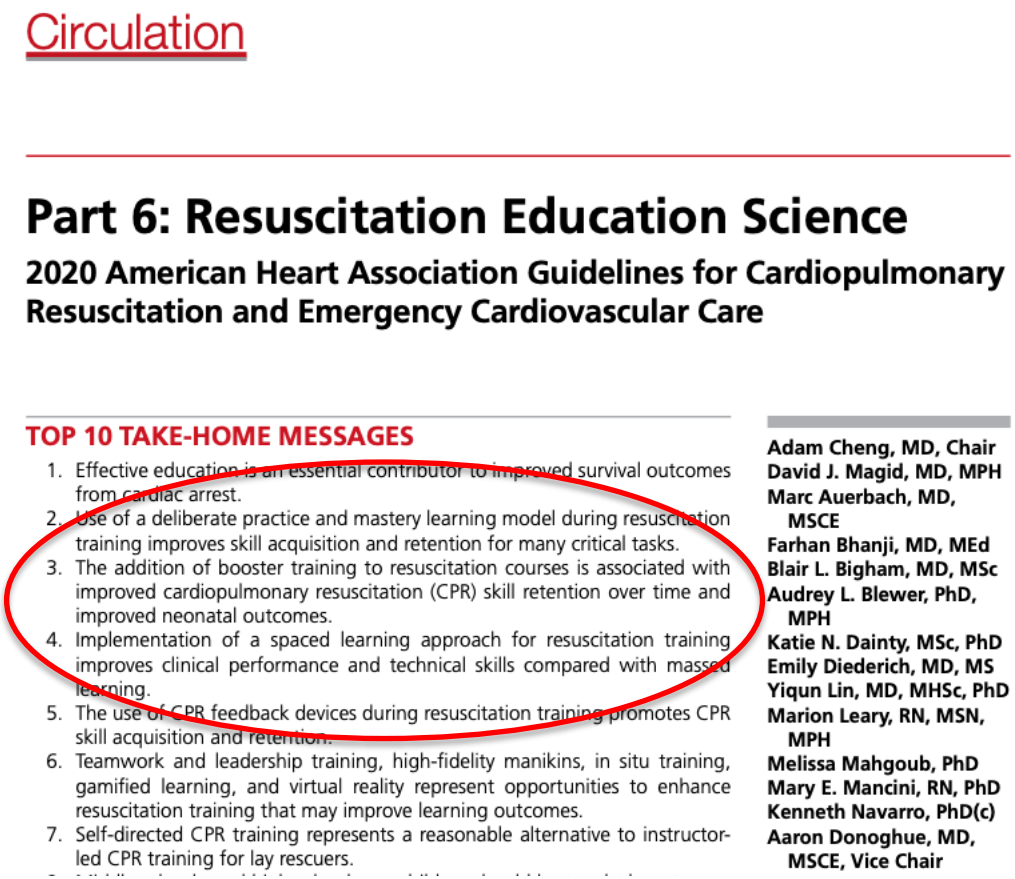
Donoghue A et al. *Resuscitation Plus* 2021

Strategy: Deliberate Practice

Training approach in which learners are given:

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

Mastery learning: couples deliberate practice training with learner assessment



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.

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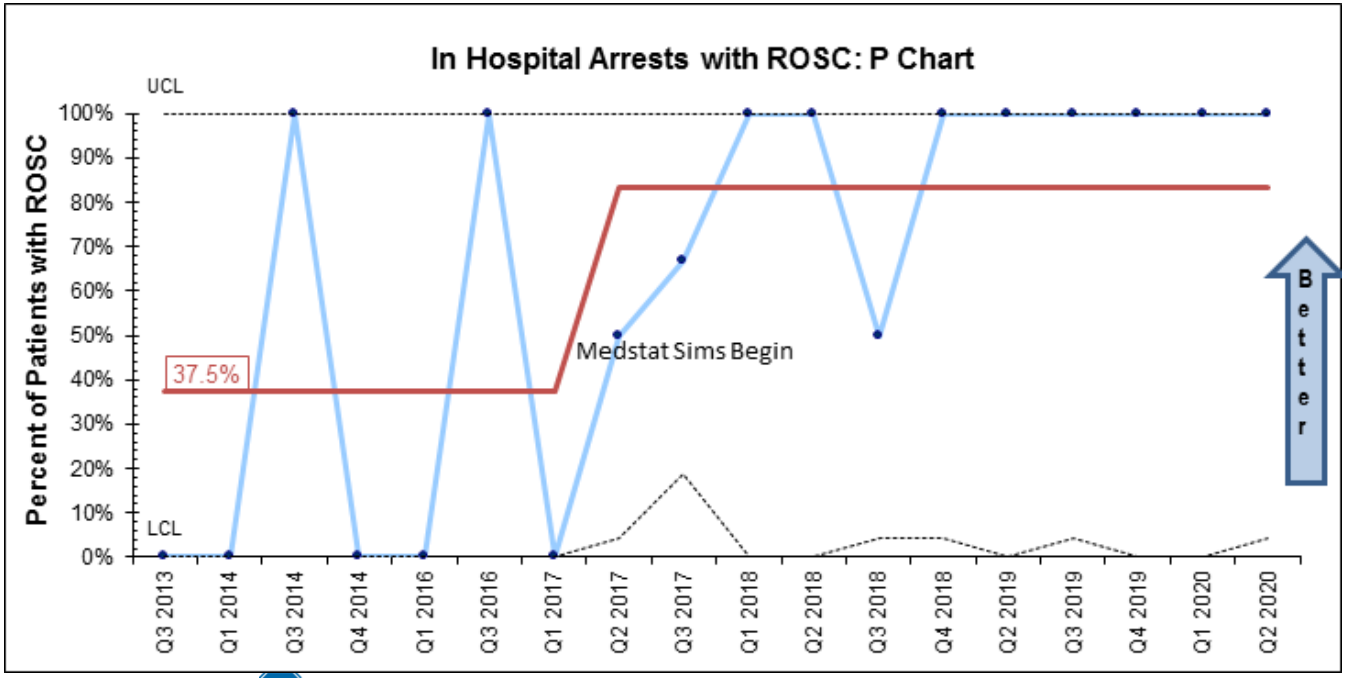
Cheng A. et al. *Circulation* 2020; Donoghue A. et al. *Resusc Plus* 2021

Yup. Even in a Level 1 Pediatric Trauma Center



Up and Coming

Point-of-Care Ultrasound (POCUS):

- May help identify Hs/Ts
- Requires significant expertise and a pause in chest compressions
- Monitoring pad obstruction
- Case reports of viable cardiac function after visualized standstill

”Inadequate pediatric evidence about its intra-arrest prognostic utility, and the task force urges great caution until more literature is available”

Up and Coming

Near-Infrared Spectroscopy (NIRS):

- Estimates regional cerebral O_2 saturation
- No-flow in cardiac arrest reflected
- Regional or global reflection?

New? Not really

- Pediatric cardiac surgery and neurosurgery
- Stroke
- Seizures

Photo credit: pbsf.com.br

Value in pediatric cardiac arrest is unknown

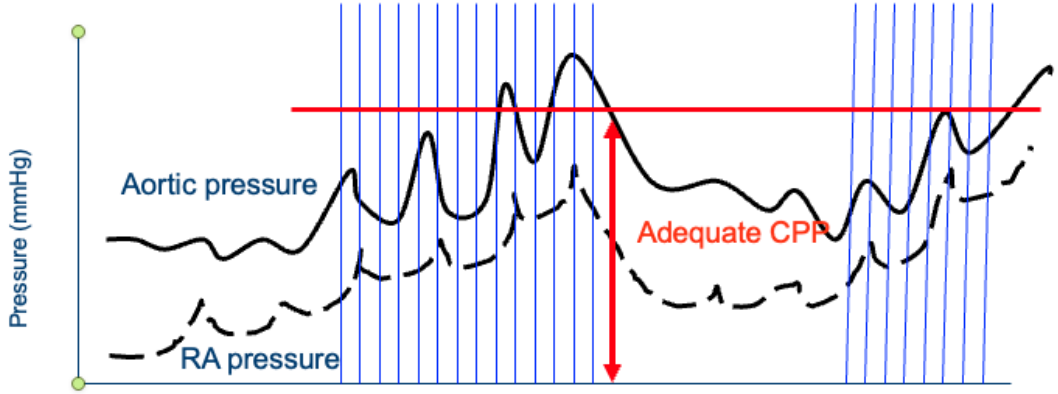
Concentrate on the Basics

Perform Quality CPR

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

Minimize Interruptions: Why It Matters

- Frequent pauses results in prolonged duration of low CPP
- Linked to lower ROSC rates



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, the answer to “what causes the longest pause” is the same: Intubation

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 greatest pause

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: No Pause?

- Intubate during continuous compressions?

Video recording review:
- Successful intubation without CPR interruption: 11/27 (41%)
  - 2 children never able to be intubated
- Successful intubation with CPR interruption: 20/32 (63%)

Conclusion: intubation during pediatric CPR results in significant interruptions in chest compressions.

Donoghue A et al. *Resuscitation* 2016

Strategies for Improvement: VL?

- Utilize videolaryngoscopy?

VL in adult cardiac arrest: data conflicting
- No difference in first-pass success for experienced intubators/paramedics
- Multicenter trial: small improvement with VL

VL in pediatric cardiac arrest: no data
- Only manikin studies: no change in FPS rate with VL during compressions
- Total intubation time less with infant DL vs VL

Kim JW et al. *Resuscitation* 2016; Risse J et al. *BMC Emerg Med* 2020; Okamoto H, et al. *Resuscitation* 2019; Rodriguez-Nunez A, et al. *Eur J Pediatr* 2014

Strategies for Improvement: No Intubation?

- 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%

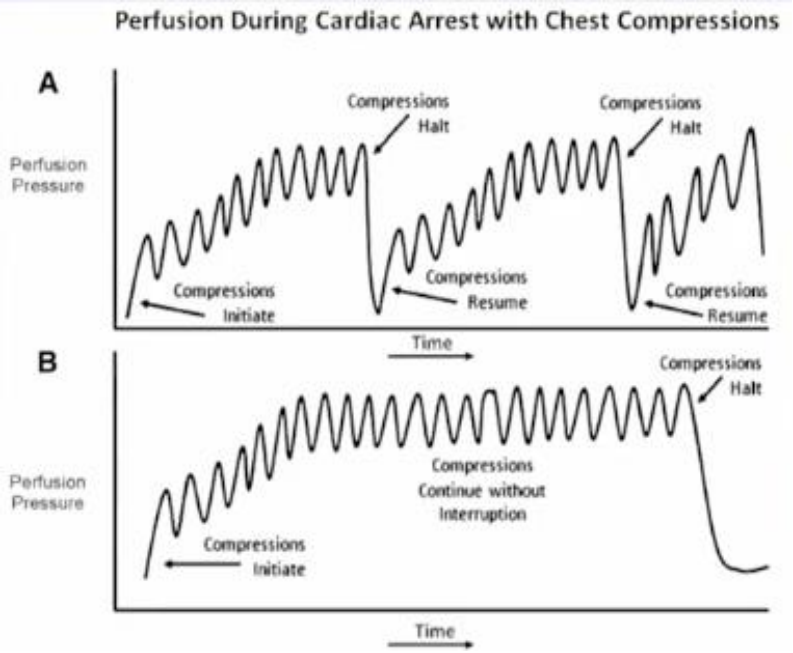
BMV associated with double the rate of survival to discharge!

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

Risks with Tracheal Plastic

- Delay in other interventions
- Provider distraction
- Risk of hyperventilation
- Risk of hyperoxia
- Interrupted compressions
- Failed ETT placement = more interruptions

Remember the Mission



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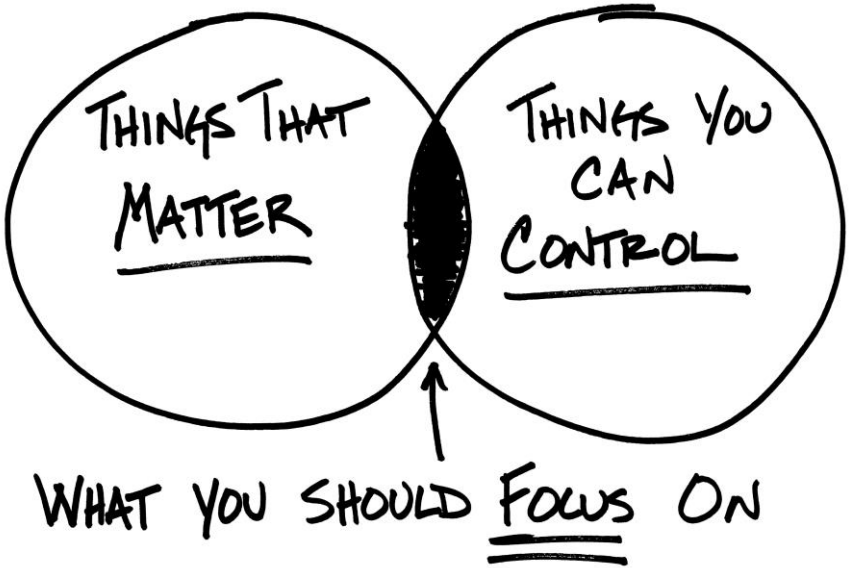
Hansen ML, et al. *Resuscitation* 2017; Benoit J et al. *Resuscitation* 2015; Cheskes S et al. *Resuscitation* 2014

Remember the Mission

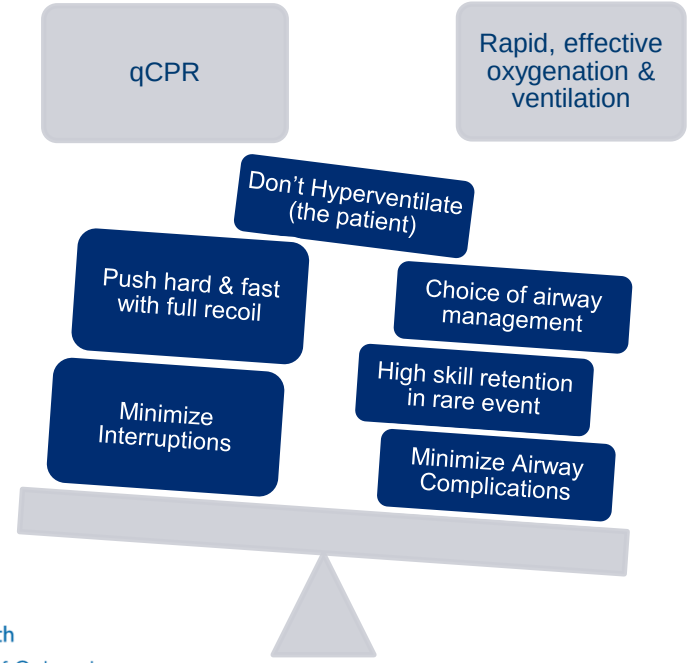


What Matters: ROSC and Neuro-intact Survival

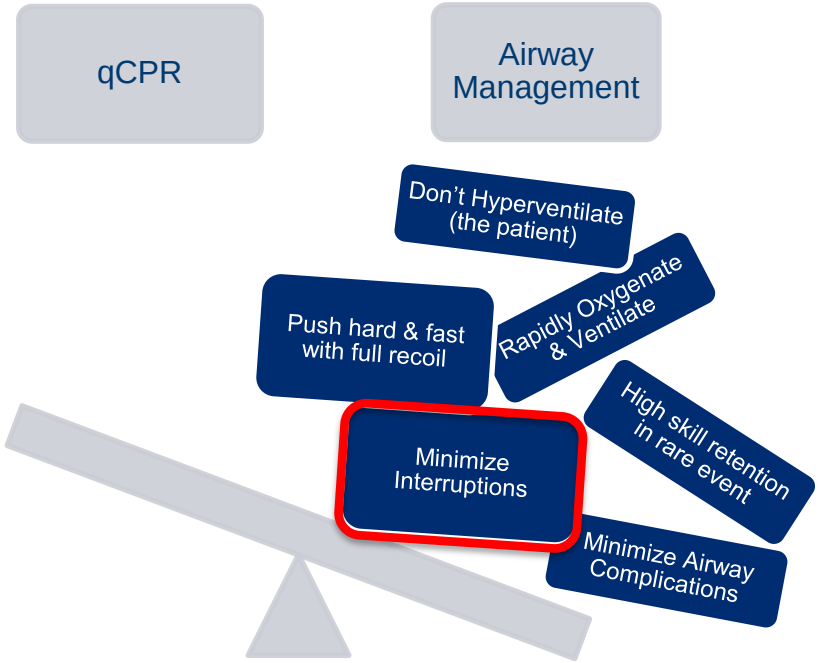
Your focus:

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

Minimizing Interruptions = Balancing Priorities



How do you Balance Priorities?



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:

- Decreased CCF: pauses impact survival
- 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

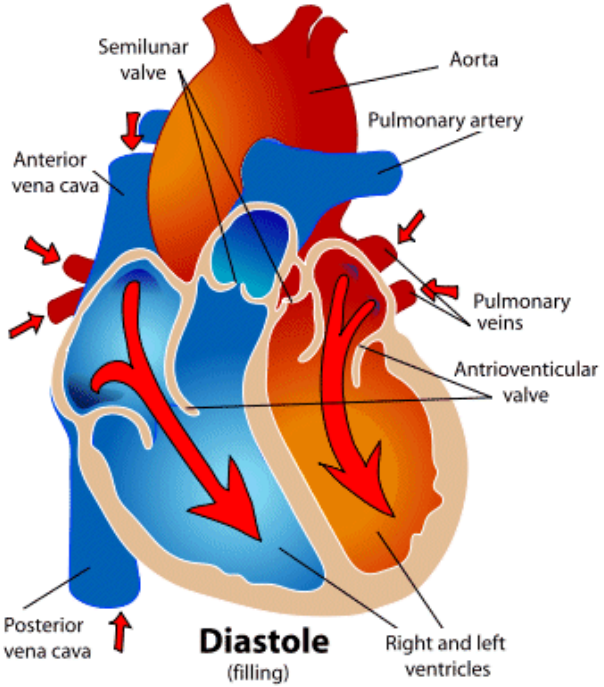
Harris M et al. *Prehosp Emerg Care* 2022; Pepe PE et al. *Crit Care* 2015; Aufderheide TP, et al. *Circulation* 2004; Niebauer et al. *Pediatrics* 2011; Mandt M et al. *Prehosp Emerg Care* 2022

Concentrate on the Basics

Perform Quality CPR

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

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

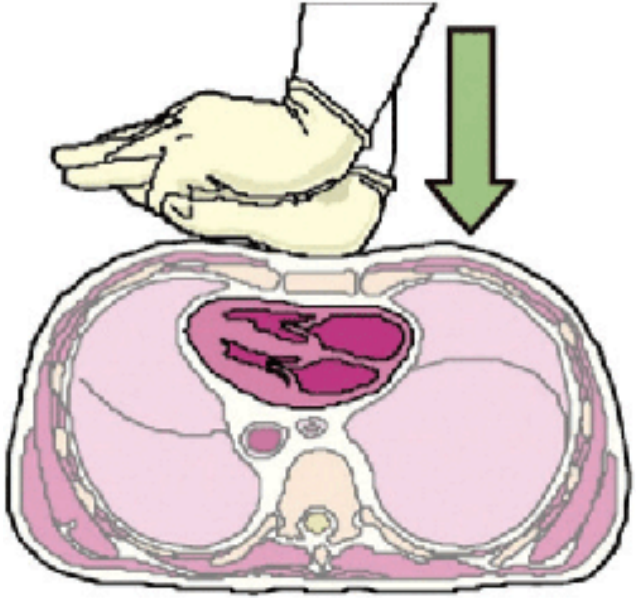

Photo credit: JEMS.com

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

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

Concentrate on the Basics

Perform Quality CPR

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

Photo credit: gagadaily.com

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).

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.

~~Respiratory Failure: 1 breath every 3 to 5 seconds (12-20bpm)~~

~~Cardiopulmonary arrest: 1 breath every 6 to 8 seconds (8-10bpm)~~

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Topjian AA, et al. *Circulation* 2020

Hyperventilation is STILL BAD!

Why do we worry about hyperventilation?

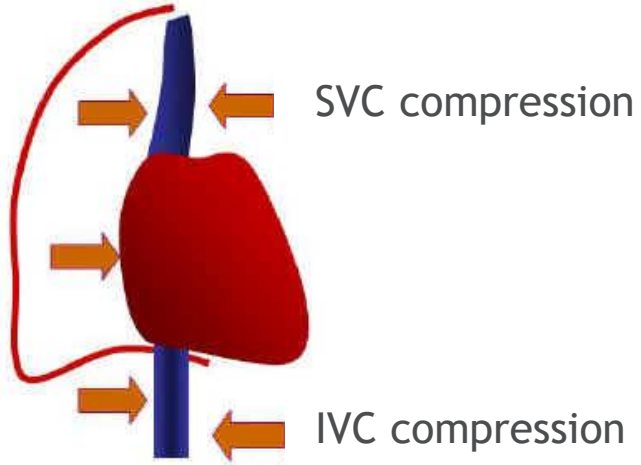

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Photo credit: bronchus technologies

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 came the interesting part:

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:

“There are insufficient data to identify the optimal tidal volume or respiratory rate.”

Acronym Response to This Data:

European Resuscitation Council:

- Provide continuous compressions when a tracheal tube is in place. Ventilate at a rate of 25 (infants) – 20 (1-8y) – 15 (8-12y) or 10 (>12y) per minute

EUROPEAN RESUSCITATION COUNCIL
GUIDELINES 2021

Community Reaction: Robust!

Concern: Not the same as OHCA population because

- Not typical 1st documented rhythm
- Patients had monitors in place and preload controlled prior to arrest
- Large separation between IHCA and OHCA for survival proves that these populations are different. Can't use an in-hospital study to make broad recommendations

AHA Response:

- Study statistics controlled for initial rhythm. Don't currently alter ventilation rate for rhythm
- Decreases confounders
- Literature shows that this is largely attributed to quality of CPR, debriefing, and post-resuscitation care received in the hospital. Controlled setting may decrease confounders.

Community Reaction: Robust!

Concern:

- Animal models have shown hyperventilation, including rates of 20-30bpm, to be linked with death

AHA Response:

- This is the first human child study on which to base human child recommendations.
- We don't know a true definition of hyperventilation in kids
- Other pediatric animal models have shown the opposite, including trend toward better ROSC rates with higher RR when comparing rates of 10,20,30 bpm.

Lopez J. et al. *PLOS One*. 2016; Lapid FM, et al. *Paediatr Anaesth* 2020

Deeper Dive: Concerns & Reasoning

Concern:

- Single, small study should not drive a change in decades-old recommendations

AHA 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.

"Overall, the evidence base in favour of 'sub-physiological' ventilation rates is weak and suffers from severe indirectness"

EUROPEAN RESUSCITATION COUNCIL GUIDELINES 2021

Deeper Dive: Concerns & Reasoning

Concern:

- This may worsen the frequency of hyperventilation

AHA Response:

- We're already 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
- Clarity expected in the next 1-2 years

Hyperventilation: Strategies for Improvement

- Use 2-person BMV technique when possible
- 1-finger technique
- Count aloud, metronome or ventilation timer
- Watch capnograph

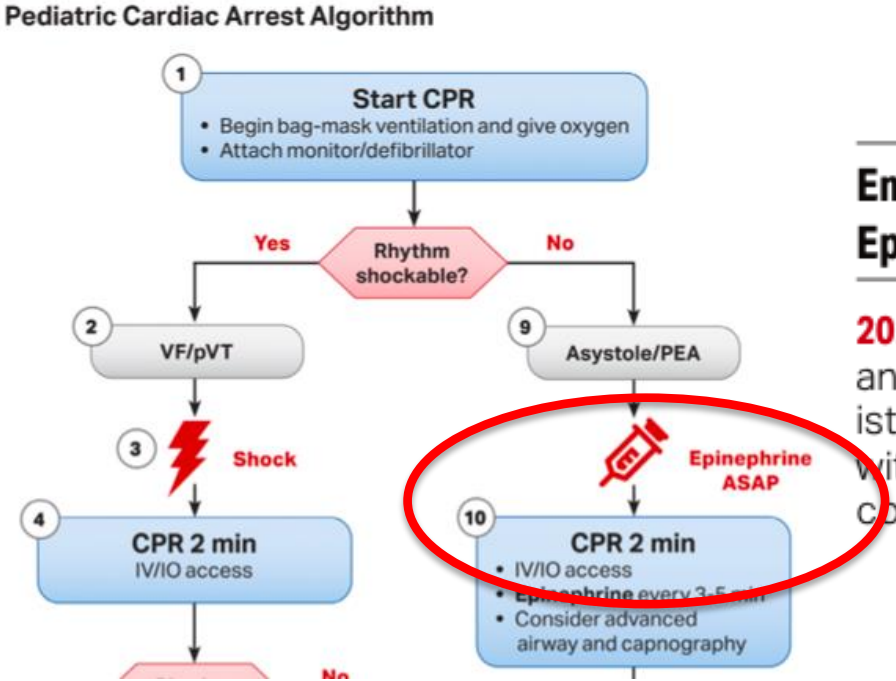
Kroll M et al. *Prehosp Emerg Med* 2019

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
4. Remember the algorithm
5. Acknowledge the secondary provider trauma
6. Debrief

Remember the Algorithm



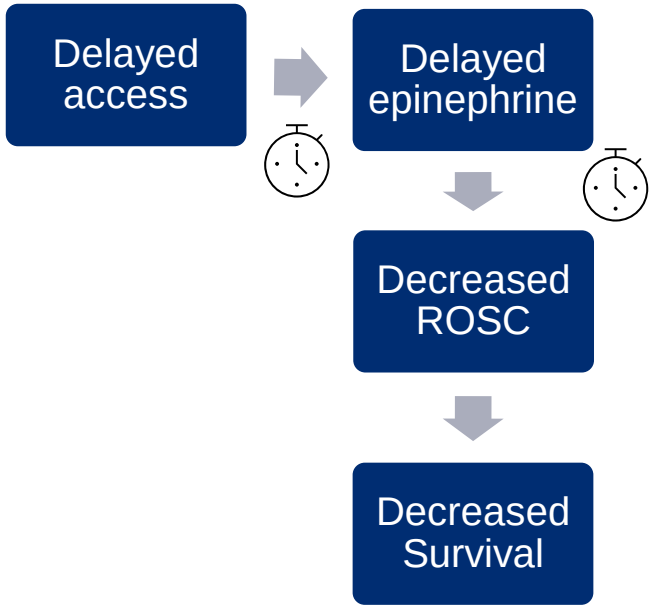
Emphasis on Early Epinephrine Administration

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



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

IO vs IV

"In the absence of evidence, recommendations remain the same"

Photo credit: www.jem-journal.com

How Critical is Early Epi?

Why the emphasis?

- In-hospital observational studies of children demonstrating:
  - Increased survival at 1 year when epi given within first 3-5 minutes of a non-shockable rhythm resuscitation
  - For every minute of delay of epinephrine, significant decrease in ROSC, survival rates

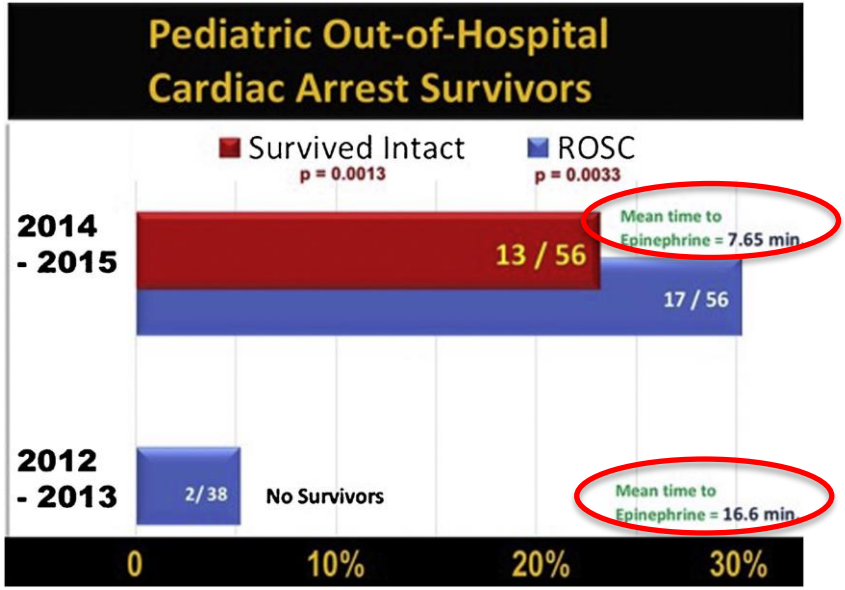
Topjian AA, et al. *Circulation* 2020, Andersen LW et al. *JAMA* 2015

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:

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

Also important!

Summary

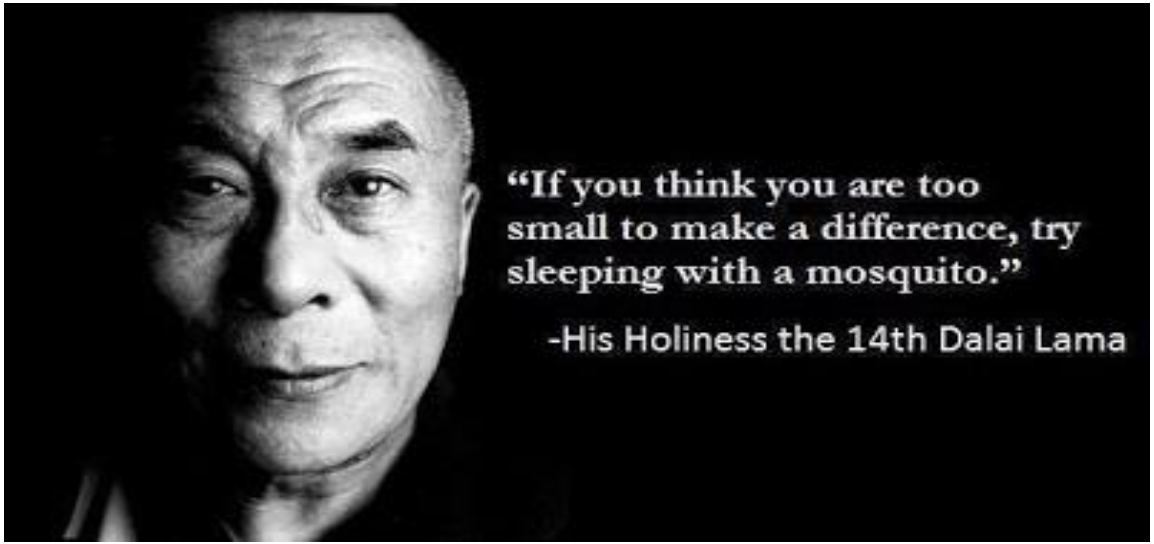
- Pediatric cardiac arrest is a rare, stressful event. Preparation is your best strategy
- It's still about quality!
- I before E, and especially before A
- Pediatric ventilation rates for kids (?)
- Use all the tools in your toolbox

Photo credit: notsalmon.com

Work It Like a Well-Oiled Machine

Video credit: collegehumor.com

Thank You, Fellow Mosquitoes!



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Thank You!