Resuscitation Updates: Optimizing Outcomes From Pediatric Cardiac Arrest

Beth Wathen MSN RN CCRN
Codes Program Coordinator
Children's Hospital Colorado

Disclosure

I have no financial relationships with ineligible companies.

Objectives

Incidence/Outcomes

High Quality Resuscitation

Post Arrest Care

Incidence/Outcomes

Incidence of Pediatric CPAs

Out of Hospital Cardiac Arrests ?

> 5000 children in US annually

Topjian AA et al. *Circulation.* 2019;140:e194–e233.
DOI: 10.1161/CIR.0000000000000697

23,514 pediatric OHCA

National Emergency Medical Services Information System (NEMSIS)
Okubo et al. Resuscitation. 2020

In Hospital Cardiac Arrests

~ 15,200 events annually

- 7100 pulseless arrests
- 8100 non-pulseless events

Holmberg MJ et al. Circulation. 2019:140(17);1398-1408.
https://doi.org/10.1161/CIRCULATIONAHA.119.041667

https://www.shutterstock.com/image-photo/newborn-baby-hyperbilirubinemia-on-breathing-machine-630739139

Cardiac Arrest Survival in Pediatric and General Emergency Departments

Kenneth A. Michelson, MD ✉; Joel D. Hudgins, MD; Michael C. Monuteaux, ScD; Richard G. Bachur, MD; Jonathan A. Finkelstein, MD

- Data from 2009-2014 Nationwide Emergency Department Sample
- Compared pediatric EDs (N=4037)to general EDs(N=42843)

Findings:

- Unadjusted survival higher in pediatric EDs than general EDs (33.8% vs 18.9%, p<.001)
- Adjusted odds ratio of survival in peds EDs vs Gen EDs was 2.2
- Survival for traumatic cardiac arrests did not differ

Michaelson KA, et al. Cardiac arrest survival in pediatric and general emergency departments. Pediatrics. 2018;141(2):e20172741.

Original Investigation | Emergency Medicine

Survival After Intra-Arrest Transport vs On-Scene Cardiopulmonary Resuscitation in Children

Masashi Okubo, MD, MS; Sho Komukai, PhD; Junichi Izawa, MD, DrPH; SunHee Chung, MD; Ian R. Drennan, ACP, PhD; Brian E. Grunau, MD, MHSc; Joshua R. Lupton, MD, MPH, MPhil; Sriram Ramgopal, MD; Thomas D. Rea, MD, MPH; Clifton W. Callaway, MD, PhD

- Data from Resuscitation Outcomes Consortium Epidemiologic Registry (2005 – 2015)
- 2854 pediatric patients with EMS-treated OHCA
- Primary outcome: survival to hospital discharge

Findings:

- 1892(66.3%) children received intra-arrest transport and 962(33.7%) received continued on scene CPR.
- No significant difference in survival to hospital discharge between the intra-arrest transport group (4.7%) and the continued on-scene CPR group(5.2%)
- For patients< 1yr, intra-arrest transport was associated with lower likelihood of survival to hospital discharge(RR 0.52;95%CI)

Okubo M et al. Survival after intra-arrest transport vs on-scene cardiopulmonary resuscitation in children. JAMA Network Open. 2024;7(5):e2411641.

Survival Trends in Pediatric In-Hospital Cardiac Arrests: An Analysis From Get With The Guidelines–Resuscitation

Saket Girotra, John A. Spertus, Yan Li, Robert A. Berg, Vinay M. Nadkarni, Paul S. Chan and for the American Heart Association Get With the Guidelines-Resuscitation Investigators

- 1031 pediatric in-hospital arrests
- 12 free-standing children's hospitals (2000 – 2009)

Characteristics/Trends over Time:

- 84.8% asystole or PEA
- More arrests in monitored units
- More arrests in ICUs, on mech ventilation, on pressors

Girota et al. *Circ Cardiovasc Qual Outcomes*. 2013.

Survival Trends in Pediatric In-Hospital Cardiac Arrests: An Analysis From Get With The Guidelines–Resuscitation

Saket Girotra, John A. Spertus, Yan Li, Robert A. Berg, Vinay M. Nadkarni, Paul S. Chan and for the American Heart Association Get With the Guidelines-Resuscitation Investigators

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- 12 free-standing children's hospitals (2000 – 2009)

Table 4. Risk-Adjusted Rates* of Survival Outcomes by Calendar Year

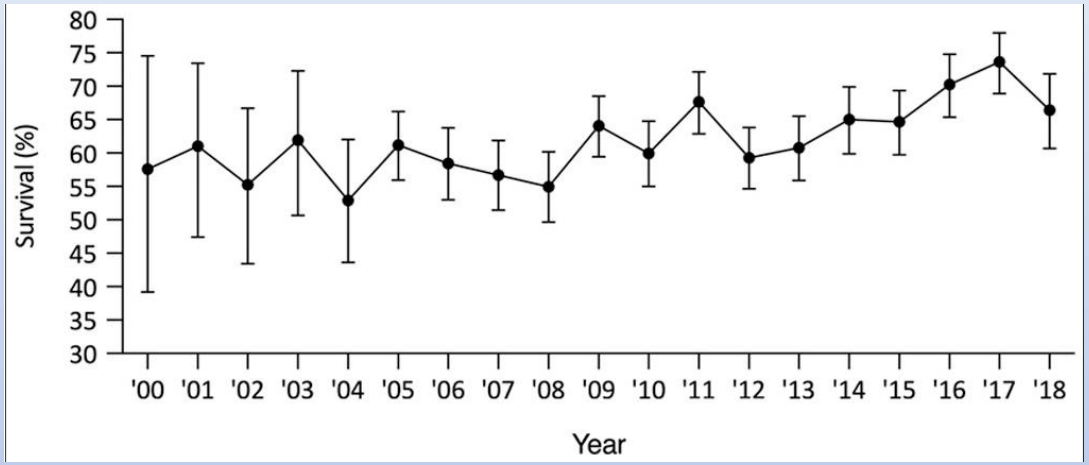
	2000 (n=28)	2001 (n=37)	2002 (n=64)	2003 (n=89)	2004 (n=98)	2005 (n=149)	2006 (n=125)	2007 (n=154)	2008 (n=193)	2009 (n=94)	Adjusted RR per 1 y (95% CI)	*P* for Trend
Survival to discharge, %	14.3	22.5	37.9	31.0	30.8	24.3	44.5	42.0	42.1	43.4	1.08 (1.01–1.16)	0.02
Acute resuscitation survival,† %	42.9	64.3	74.9	55.6	72.3	63.3	79.7	74.6	80.3	81.2	1.04 (1.01–1.07)	0.006
Postresuscitation survival,‡ %	33.3	36.3	49.8	53.1	42.4	38.9	56.4	56.7	52.5	53.6	1.04 (0.98–1.09)	0.17

Girota et al. *Circ Cardiovasc Qual Outcomes*. 2013.

Trends in Survival After Pediatric In-Hospital Cardiac Arrest in the United States

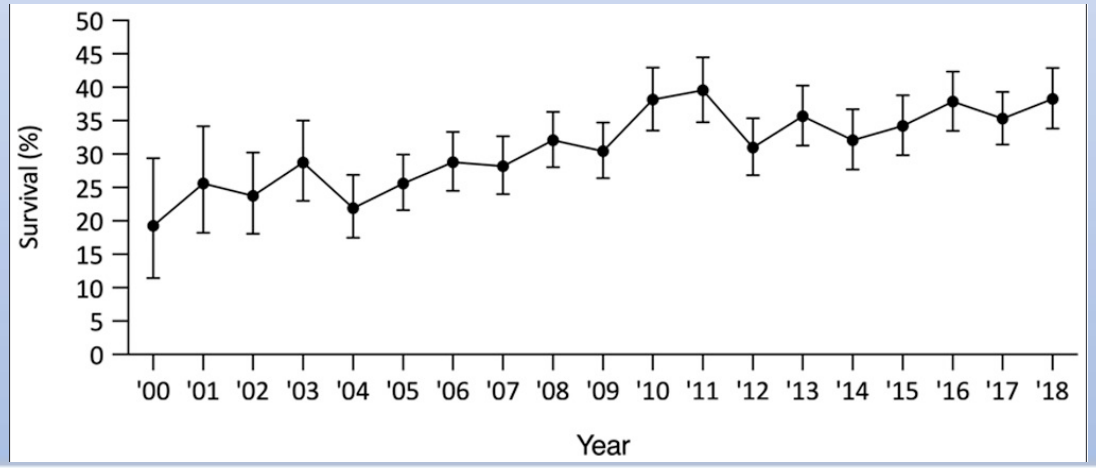
Mathias J. Holmberg ✉, Sebastian Wiberg, Catherine E. Ross, Monica Kleinman, Anne Kirstine Hoeyer-Nielsen, Michael W. Donnino, Lars W. Andersen and For the American Heart Association's Get With The Guidelines-Resuscitation Investigators

Survival Trends for Non-Pulseless Events



Improvement has stagnated since 2010

Survival Trends for Pulseless Events



Holmberg MJ et al. Circulation. 2019:140(17);1398-1408.
https://doi.org/10.1161/CIRCULATIONAHA.119.041667

Characteristics of Pediatric IHCA

Table 1. Characteristics of Pediatric vs Adult In-Hospital Cardiac Arrest

Characteristic	Pediatric patients[3-5,7]	Adult patients[4,6,7]
Incidence	Approximately 15 200/y in United States	Approximately 292 000/y in United States
Age	Median: 1-2 y; mean: 3-5 y[a]	Mean: 66 y
Male sex	50%-55%	60%
Hospital location	85%-90% In monitored settings[b]	50% In monitored settings[b]
Airway in place	Approximately 80%	Approximately 30%-35%
Cause of cardiac arrest	Most with respiratory failure and/or progressive shock	50%-60% Cardiac; 15%-40% respiratory
Initial cardiac arrest rhythm	50% Bradycardia with poor perfusion; 40% other nonshockable rhythms	80% Nonshockable rhythms (pulseless electrical activity or asystole)
Survival to discharge	45%-50% (40% Among those with pulseless events)	25%
Neurological outcome	Favorable in 80%-90% of survivors[c]	Good functional status in 80% of survivors[d]

Bradycardia with poor perfusion

- Best outcomes
- However….
  - 30-50% will go on to develop pulseless rhythm
  - These patients have worse outcomes then those initially pulseless

Shockable rhythms:

- Generally better outcome
- However….
  - IF V-fib or V-tach develop as a secondary rhythm after initial pea or asystole rhythm → worse outcome of all

Morgan et al. *JAMA Peds*. 2021.

Other Factors Impacting Outcomes

Med Care. 2016 Jan;54(1):74-80. doi: 10.1097/MLR.0000000000000456.

Better Nurse Staffing and Nurse Work Environments Associated With Increased Survival of In-Hospital Cardiac Arrest Patients

Matthew D McHugh [1], Monica F Rochman, Douglas M Sloane, Vinay M Nadkarni, Raina M Merchant, Linda H Aiken; American Heart Association's Get With The Guidelines-Resusc

Eur J Pediatr. 2021 Aug;180(8):2513-2520. doi: 10.1007/s00431-021-04082-3. Epub 2021 Apr 26.

Survival outcomes of in-hospital cardiac arrest in pediatric patients in the USA

Mohammed Hamzah [# 1], Hasan F Othman [# 2], Murad Almasri [3], Awni Al-Subu [4], Riad Lutfi [5]

Affiliations + expand

PMID: 33899153 DOI: 10.1007/s00431-021-04082-3

Failure of Invasive Airway Placement on the First Attempt Is Associated With Progression to Cardiac Arrest in Pediatric Acute Respiratory Compromise

Hannah R. Stinson, MD[1]; Vijay Srinivasan, MD[2]; Alexis A. Topjian, MD, MSCE[2]; Robert M. Sutton, MD, MSCE[2]; Vinay M. Nadkarni, MD[2]; Robert A. Berg, MD[2]; Tia T. Raymond, MD[3]; for the American Heart Association Get With the Guidelines-Resuscitation Investigators

Stinson HR et al. *Pediatr Crit Care Med*. 2018;19(1):9-16.

How do we get there?

How do we nudge the needle?

ROSC → **Survival to Discharge**

80-90% **40%**

High quality resuscitation → **High quality post arrest care**

Patient Outcome → **Optimal Patient outcome**

High Quality Resuscitation

AHA CONSENSUS STATEMENT

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, Marion Leary

> “Poor-quality CPR should be considered a preventable harm”

Key Components of High-Quality CPR

- Appropriate ventilation and airway management
- Early Defibrillation if indicated
- High quality chest compressions
- Epinephrine administration
- Treat underlying cause of the arrest

Morgan et al. *JAMA Pediatrics.* 2021.

Ventilation

- Avoidance of hyperventilation
- Goal is to optimize myocardial blood flow, maintain oxygenation and CO2 clearance
- Target visible chest rise
- Target 1 breath every 2-3 seconds (20-30 breaths/min)
- For OHCA, bag/mask ventilation results in same resuscitation outcomes than endotracheal intubation

https://www.shutterstock.com/image-photo/neonatal-reanimation-medical-instruction-young-doctors-1551168578

Topjian AA et al. *Circulation. 2020: 142(16);S469-S523.*

Intubation During CPR

Association Between Tracheal Intubation During Pediatric In-Hospital Cardiac Arrest and Survival

Findings:

Tracheal intubation during cardiac arrest compared with no intubation was associated with decreased survival to hospital discharge.

Anderson LW et al. JAMA 2016;316(17):1786-1797. doi: 10.1001/jama.2016.14486.

Association Between Tracheal Intubation During Adult In-Hospital Cardiac Arrest and Survival

Lars W. Andersen, MD, MPH, PhD[1,2,3]; Asger Granfeldt, MD, PhD, DMSc[2]; Clifton W. Callaway, MD, PhD[4]; et al

Findings:

Tracheal intubation within first 15 minutes was associated with a significantly lower likelihood of survival to hosp. discharge compared to no intubation. (16.3% vs 19.4%)

Anderson LW et al. JAMA 2017.

Defibrillation

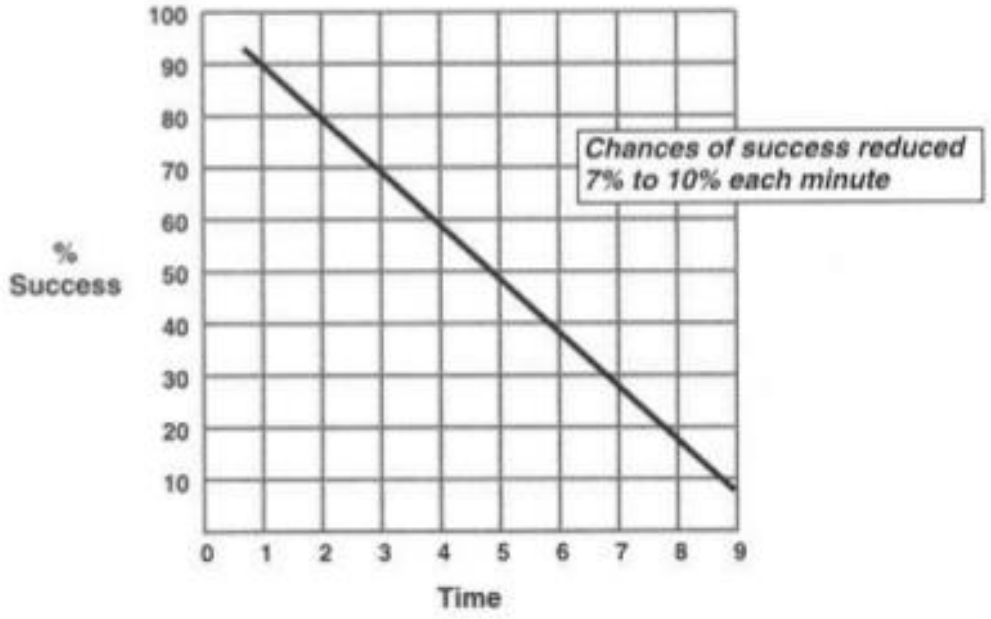
Early Defibrillation

AED vs Defibrillator

Peri-Shock Pauses

Early Defibrillation

Early Defibrillation = Increased Survival



Larsen MP et al. *Ann Emerg Med*. 1993;22(11):1682-8.
doi: 10.1016/s0196-0644(05)81302-2.

Automated External Defibrillators and Survival After In-Hospital Cardiac Arrest

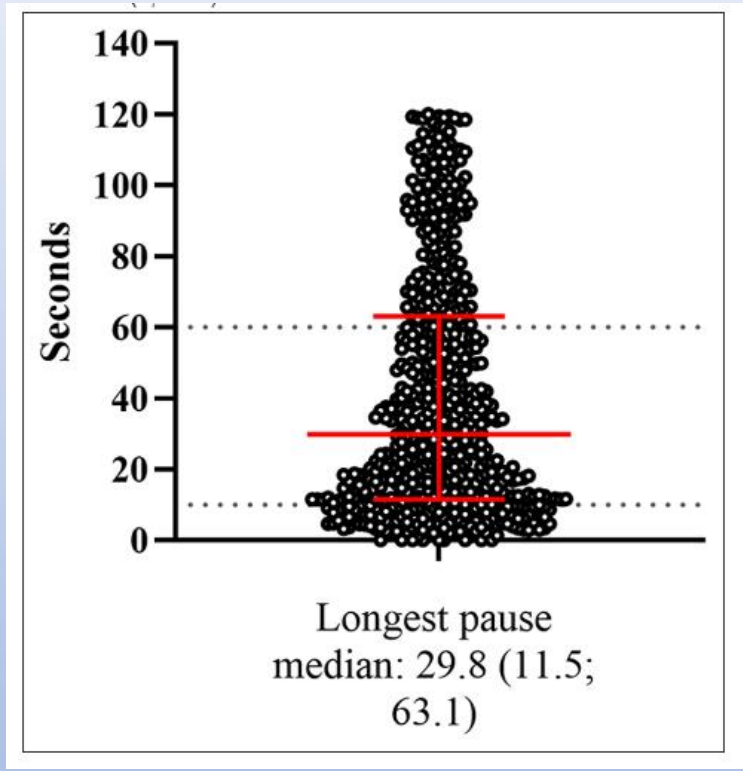
- 11,695 patients
- 82% non-shockable rhythm

Table 3. Survival to Discharge[a]

	No. of Survivors/Total No. of Patients (%)		Unadjusted RR (95% CI)	Adjusted RR (95% CI)[b]	*P* Value
	AED Used	AED Not Used			
All units					
All arrests	734/4515 (16.3)	1383/7180 (19.3)	0.84 (0.78-0.92)	0.85 (0.78-0.92)	<.001
VF and pulseless VT	364/947 (38.4)	450/1132 (39.8)	0.97 (0.87-1.08)	1.00 (0.88-1.13)	.99
Asystole and PEA	370/3568 (10.4)	933/6048 (15.4)	0.67 (0.60-0.75)	0.74 (0.65-0.83)	<.001

Chan et al. *JAMA*, 2010.

Association Between Chest Compression Pause Duration and Survival After Pediatric In-Hospital Cardiac Arrest



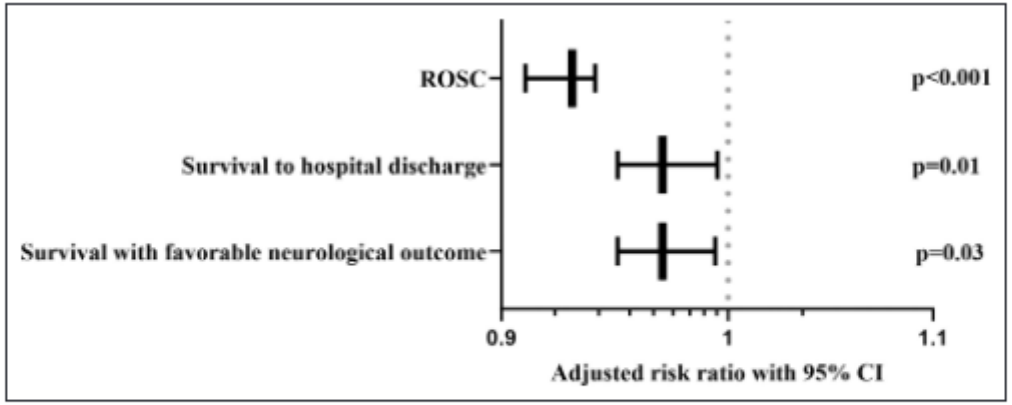


Figure 2. Association between each 5-second increment in the longest chest compression pause duration and survival outcomes reported as adjusted risk ratios with 95% CIs on a logarithmic scale. ROSC indicates return of spontaneous circulation.

Chest Compression Fraction

- % of time that compressions are being delivered while patient is in a no flow state

AHA recommends CCF of at least 80% or >

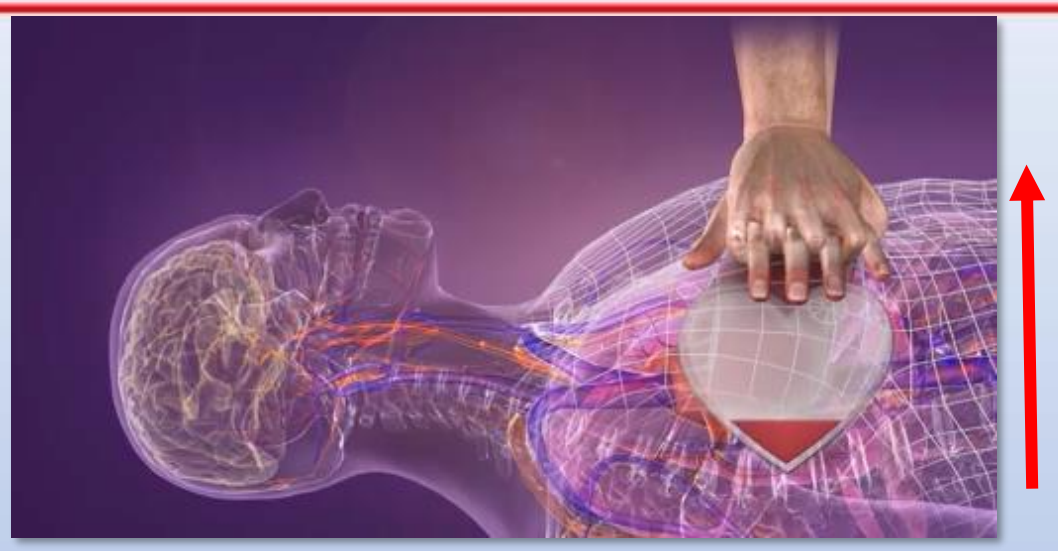
What does this mean?

- Early compressions
- Limit Interruptions
- Limit peri-shock pauses

Compressions

Permission Obtained by ZOLL Medical

- Generates positive pressure
- Creates cardiac output
- Forces air out



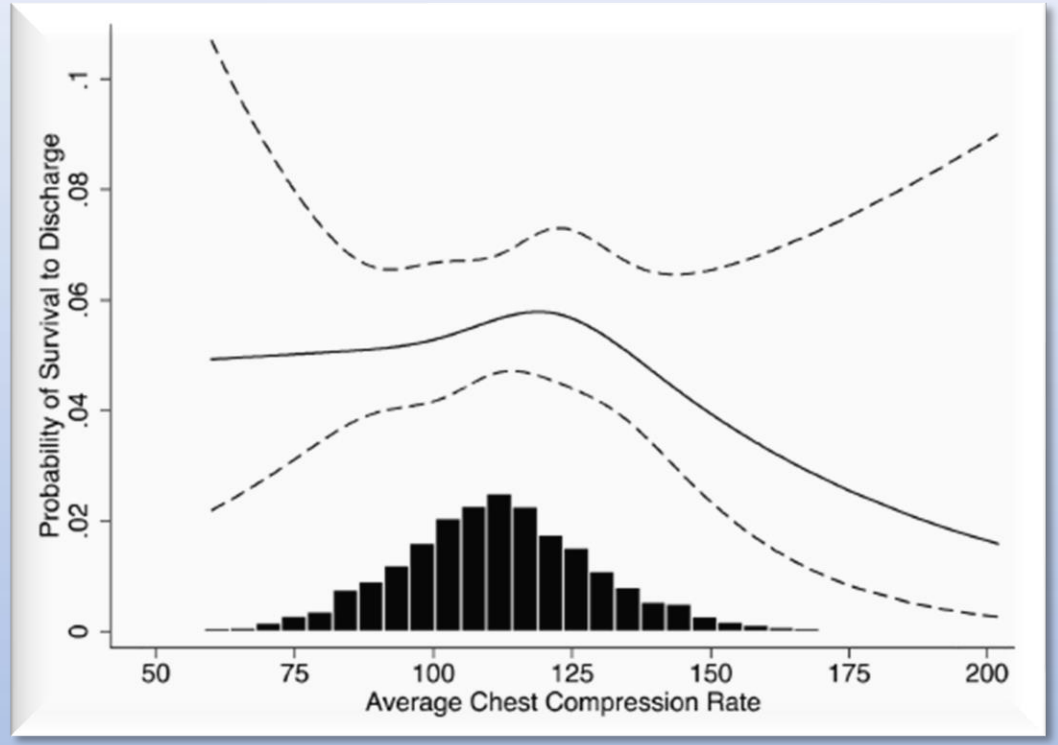
Permission Obtained by ZOLL Medical

- Negative intrathoracic pressure
- Allows heart to fill (pre-load)
- Air flows in

Rate/Depth

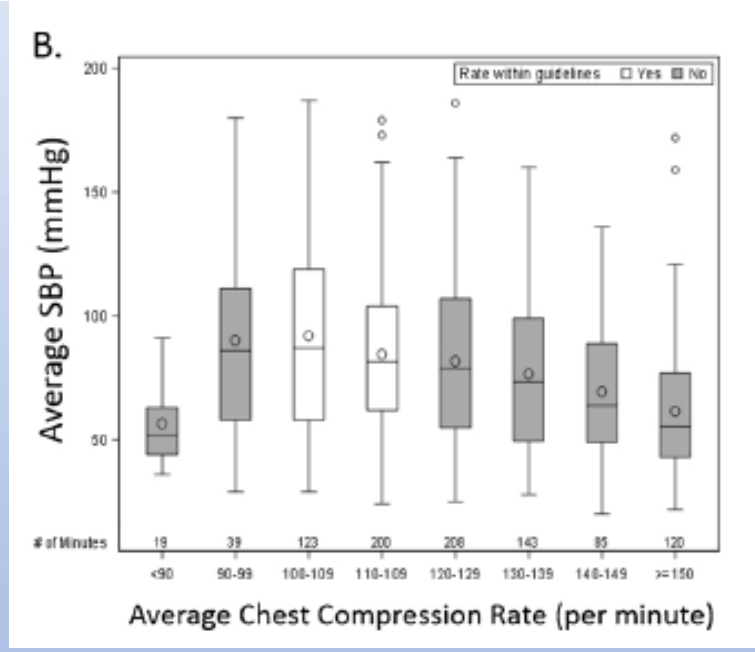
Recoil/Release

Compression Rate



Idris et al. Circulation. 2012 June 19; 125(24): 3004–3012. doi:10.1161/CIRCULATIONAHA.111.059535.

Chest compression rates and pediatric in-hospital cardiac arrest survival outcomes☆



Sutton et al. Chest compression rates and pediatric in-hospital lcardiac arrest survival outcomes. Resuscitation. 2018.

Comparing the two-finger versus two-thumb technique for single person infant CPR: A systematic review and meta-analysis

- Meta-analysis of 20 studies

Results:

- Found 2 thumb technique had mean difference in compression depth of 5.61mm greater than using the two finger technique
- 36% more compressions achieved adequate depth

https://www.shutterstock.com/image-photo/infant-assistance-medical-worker-wfp-isolate-1014228094

Millin MG et al. et al. *Resuscitation. 2020;1(148):161-172.*
doi: 10.1016/j.resuscitation.2019.12.039.

How do we know if we are doing good CPR?

TABLE 4. Event-Level Compliance: Greater Than 60% of Event's Epochs Compliant With American Heart Association Guideline Targets, *n* (%)

Metrics	Total	< 1 yr	1 to < 8 yr	8 to < 18 yr	*p*
Events	112 (100)	38 (34)	42 (38)	32 (29)	
CC fraction	79 (71)	20 (53)	34 (81)	25 (78)	< 0.001
CC rate	53 (47)	12 (32)	21 (50)	20 (63)	< 0.02
CC depth[a,b]	27 (24)	5 (13)	8 (19)	14 (44)	0.004
Absolute[c]		0 (0)	3 (7)		0.3
CC fraction and CC rate	31 (28)	8 (21)	11 (26)	12 (38)	0.3
CC fraction and CC depth[a,b]	15 (13)	3 (8)	6 (14)	6 (19)	0.006
Absolute[c]		0 (0)	2 (5)		0.24
CC rate and CC depth[a,b]	10 (8.9)	2 (5)	2 (5)	6 (19)	0.003
Absolute[c]		0 (0)	1 (2)		1.0
CC fraction, CC rate, and CC depth[a,b]	11 (10)	3 (8)	1 (2)	7 (22)	0.40
Absolute[c]		0 (0)	1 (2)		1.0

Niles DE, et al. Peds Crit Care Med. May 2018

How do we know if we are doing good CPR?

ORIGINAL RESEARCH

Poor Concordance of One-Third Anterior–Posterior Chest Diameter Measurements With Absolute Age-Specific Chest Compression Depth Targets in Pediatric Cardiac Arrest Patients

- Infants: Mean 1/3 APD was 3.2cm (SD, 0.7cm) → AHA Target is 4cm ($p < 0.0001$)
- Children: Mean one-third was 4.3 cm (SD, 1.1cm) → AHA Target is 5cm (p,0.05)

Conclusion:

Poor concordance btwn measured 1/3 APD and age-specific chest compression depth targets, most notably in infants

Ong et al. Journal of the American Heart Association. 2023

How do we know if we are doing good CPR?

- Presence of pulse during compressions
- EtCO2 Waveform Monitoring
- CPR Feedback
- Hemodynamic-directed CPR

Associations Between End-Tidal Carbon Dioxide During Pediatric Cardiopulmonary Resuscitation, Cardiopulmonary Resuscitation Quality, and Survival

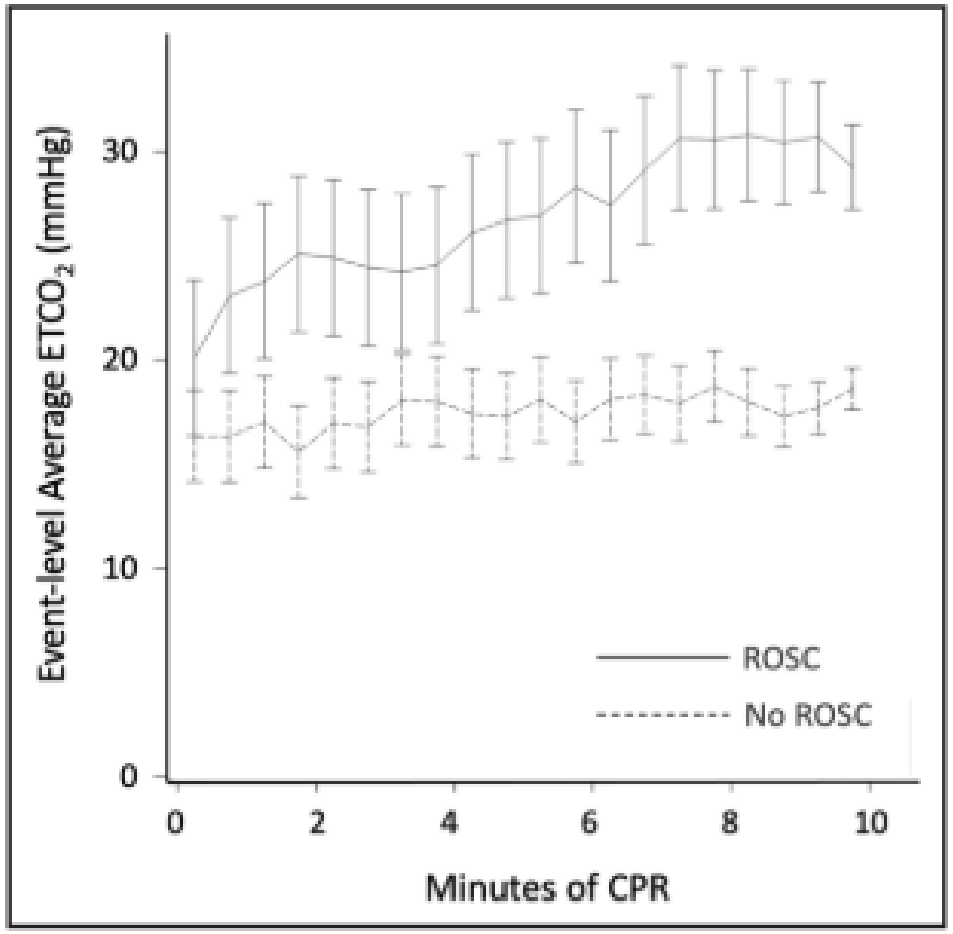


Figure 3. Temporal relationship between $ETCO_2$ during the first 10 minutes of CPR and return of spontaneous circulation.

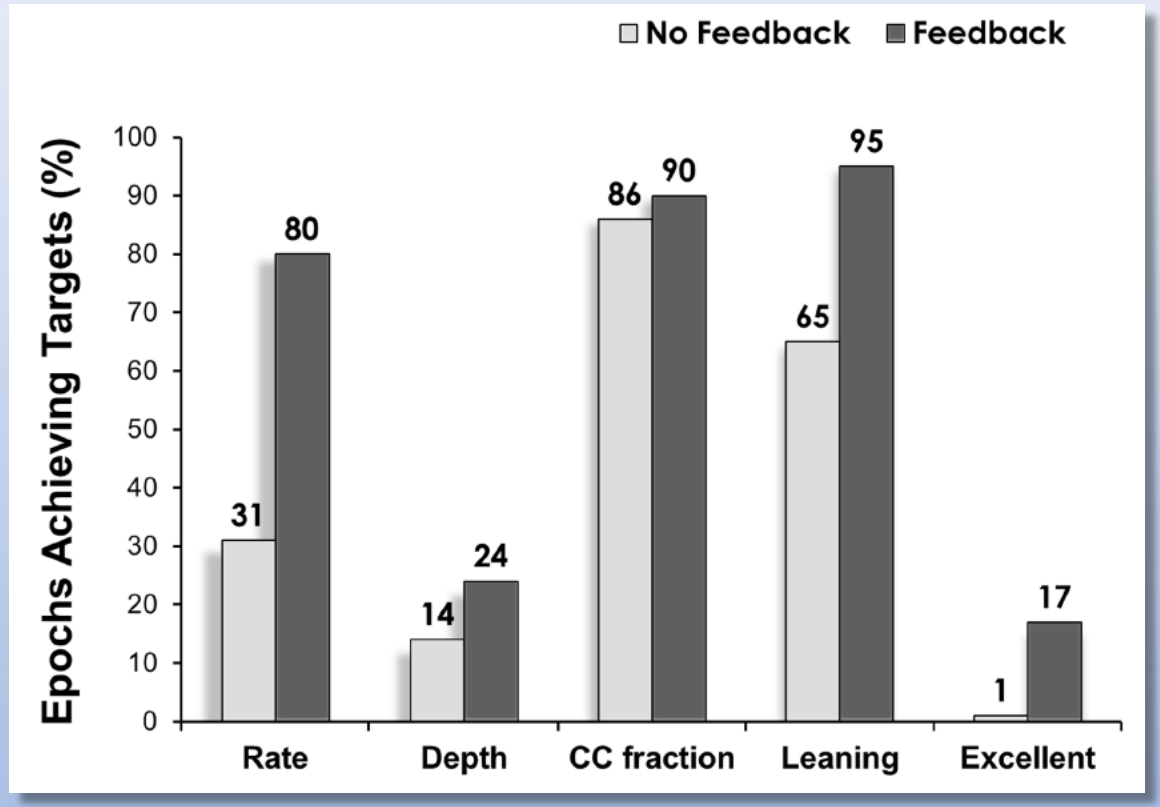
Morgan RW, et al. Circulation. 2024

CPR Feedback via the Defibrillator

- Rate and Depth display
- CPR Metronome
- Compression release bar
- CPR Index
- Idle Time Display

Do you use a CPR coach?

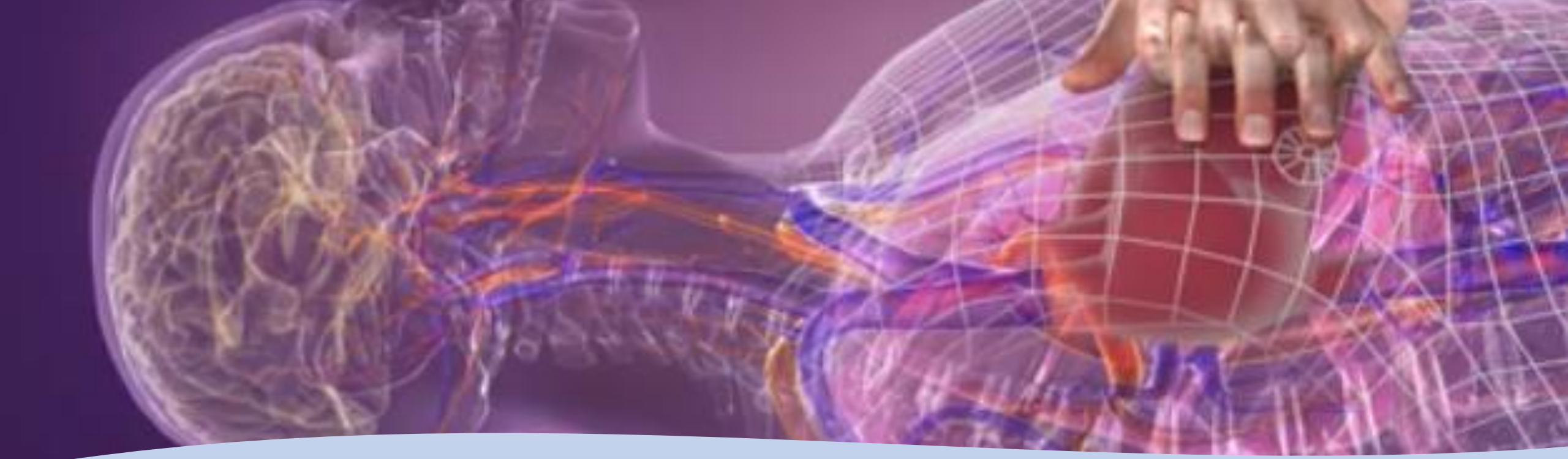
Improvement Using CPR feedback



Sutton RM, et al. Resuscitation. 2014 January; 85(1)

Hemodynamic-directed CPR

- Current AHA guidelines propose a simplified evidenced-based approach for both OHCA and IHCA.
  - Standard rate/depth
- 2013 AHA Guidelines recommend monitoring a patient's response to resuscitation using hemodynamic data or EtCO2
- Ward versus ICU arrests have shifted
  - 95% of pediatric arrests in ICU
  - 50% of ICU patients had arterial monitoring at time of arrest



Permission Obtained by ZOLL Medical

Coronary Perfusion Pressure (CPP)

- Survival after CPR is dependent on myocardial oxygen delivery and blood flow
- CPP during relaxation phase is best determinant of blood flow

Goal Arterial Diastolic BP ≥ 25 mmHg in infants

Goal Arterial Diastolic BP ≥ 30 mmHg in children

Circulation. 2017 Dec 26. pii: CIRCULATIONAHA.117.032270. doi: 10.1161/CIRCULATIONAHA.117.032270. [Epub ahead of print]

Association Between Diastolic Blood Pressure During Pediatric In-Hospital Cardiopulmonary Resuscitation and Survival.

- CPCCRN Study: 164 children with CPR > 1 min
- Analyzed arterial waveforms

Findings:

- Mean DBP ≥25 mm Hg in infants and ≥30 mm Hg in children ≥1 year old occurred was associated with:
  - **Survival to Discharge** (adjusted relative risk, 1.7; 95% confidence interval, 1.2-2.6; *P*=0.007)
  - **Survival with favorable neurological outcome** (adjusted relative risk, 1.6; 95% confidence interval, 1.1-2.5; *P*=0.02)

Berg et al. *Circulation. 2017*

New ECMO Studies

Extracorporeal cardiopulmonary resuscitation for cardiac arrest: An updated systematic review

Mathias J Holmberg [1], Asger Granfeldt [2], Anne-Marie Guerguerian [3], Claudio Sandroni [4], Cindy H Hsu [5], Ryan M Gardner [6], Peter C Lind [2], Mark A Eggertsen [7], Cecilie M Johannsen [7], Lars W Andersen [8]

Resuscitation. 2023 Jan:182:109665. doi: 10.1016/j.resuscitation.2022.12.003.

CPR quality and outcomes after extracorporeal life support for pediatric In-Hospital cardiac arrest

Brown SR et al. *Resuscitation*. 2023.

Outcomes of Extracorporeal Cardiopulmonary Resuscitation for In-Hospital Cardiac Arrest Among Children With Noncardiac Illness Categories

Morgann Loaec [1 2], Adam S Himebauch [1 2], Ron Reeder [3], Jessica S Alvey [3], Jonathan A Race [3], Lillian Su [4], Javier J Lasa [5], Julia C Slovis [1 2], Tia T Raymond [6], Ryan Coleman [7], Bradley J Barney [3], Todd J Kilbaugh [1 2], Alexis A Topjian [1 2], Robert M Sutton [1 2], Ryan W Morgan [1 2]; American Heart Association's Get With The Guidelines-Resuscitation Investigators

Crit Care Med. 2023 Dec 29. doi: 10.1097/CCM.0000000000006153.

New ECMO Studies

AHA FOCUSED UPDATE

2019 American Heart Association Focused Update on Pediatric Advanced Life Support

An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Recommendation—Updated 2019

1. **ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (*Class 2b; Level of Evidence C-LD*).**

There is insufficient evidence to recommend for or against the use of ECPR for pediatric patients experiencing OHCA or for pediatric patients with noncardiac disease experiencing IHCA refractory to conventional CPR.

ILCOR SUMMARY STATEMENT

2023 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations:

Treatment Recommendations (Unchanged From 2021)

We suggest that ECPR may be considered as an intervention for selected infants and children (eg, pediatric cardiac populations) with IHCA refractory to conventional CPR in settings where resuscitation systems allow ECPR to be well performed and implemented (weak recommendation, very low–certainty evidence).

Clinical paper

Association of chest compression pause duration prior to E-CPR cannulation with cardiac arrest survival outcomes

- Pedi-RESQ Collaborative
- Included 49 CPA events in review

Findings:

- Long chest compression pauses common in last 5 minutes of CPR prior to cannulation
- Each 5 second incremental increase in pause duration associated with significantly decreased rates of survival and favorable neurological outcome

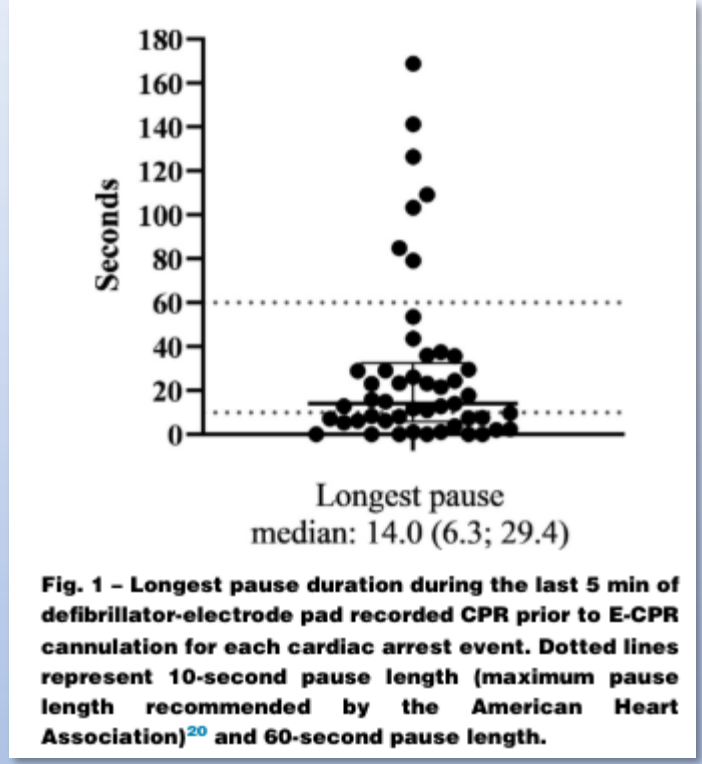


Fig. 1 – Longest pause duration during the last 5 min of defibrillator-electrode pad recorded CPR prior to E-CPR cannulation for each cardiac arrest event. Dotted lines represent 10-second pause length (maximum pause length recommended by the American Heart Association)[20] and 60-second pause length.

Lauridsen KG et al. *Resuscitation*. 2022.

Should We Shock and Other Questions

Inappropriate Shock Delivery Is Common During Pediatric In-Hospital Cardiac Arrest

Gray, James M. MD, MEd[1,2]; Raymond, Tia T. MD[3]; Atkins, Dianne L. MD[4]; Tegtmeyer, Ken MD[1,5]; Niles, Dana E. MS[6]; Nadkarni, Vinay M. MD[6]; Pandit, Sandeep V. PhD[7]; Dewan, Maya MD, MPH[1,5]; for the pediRES-Q Investigators

Gray JM et al. *Pediatr Crit Care Med*. 2023.

Sodium bicarbonate administration during in-hospital pediatric cardiac arrest: A systematic review and meta-analysis

Chih-Yao Chang [1], Po-Han Wu [1], Cheng-Ting Hsiao [2], Chia-Peng Chang [1], Yi-Chuan Chen [3], Kai-Hsiang Wu [4]

Chang CC et al. *Resuscitation*. 2021.

Calcium use during paediatric in-hospital cardiac arrest is associated with worse outcomes

Katherine Cashen [1], Robert M Sutton [2], Ron W Reeder [3], Tageldin Ahmed [4], Michael J Bell [5],

Cashen K et al. *Resuscitation*. 2023.

Post Arrest Care

https://www.shutterstock.com/image-photo/neonatal-resuscitation-doctors-team-doing-intensive-613125116

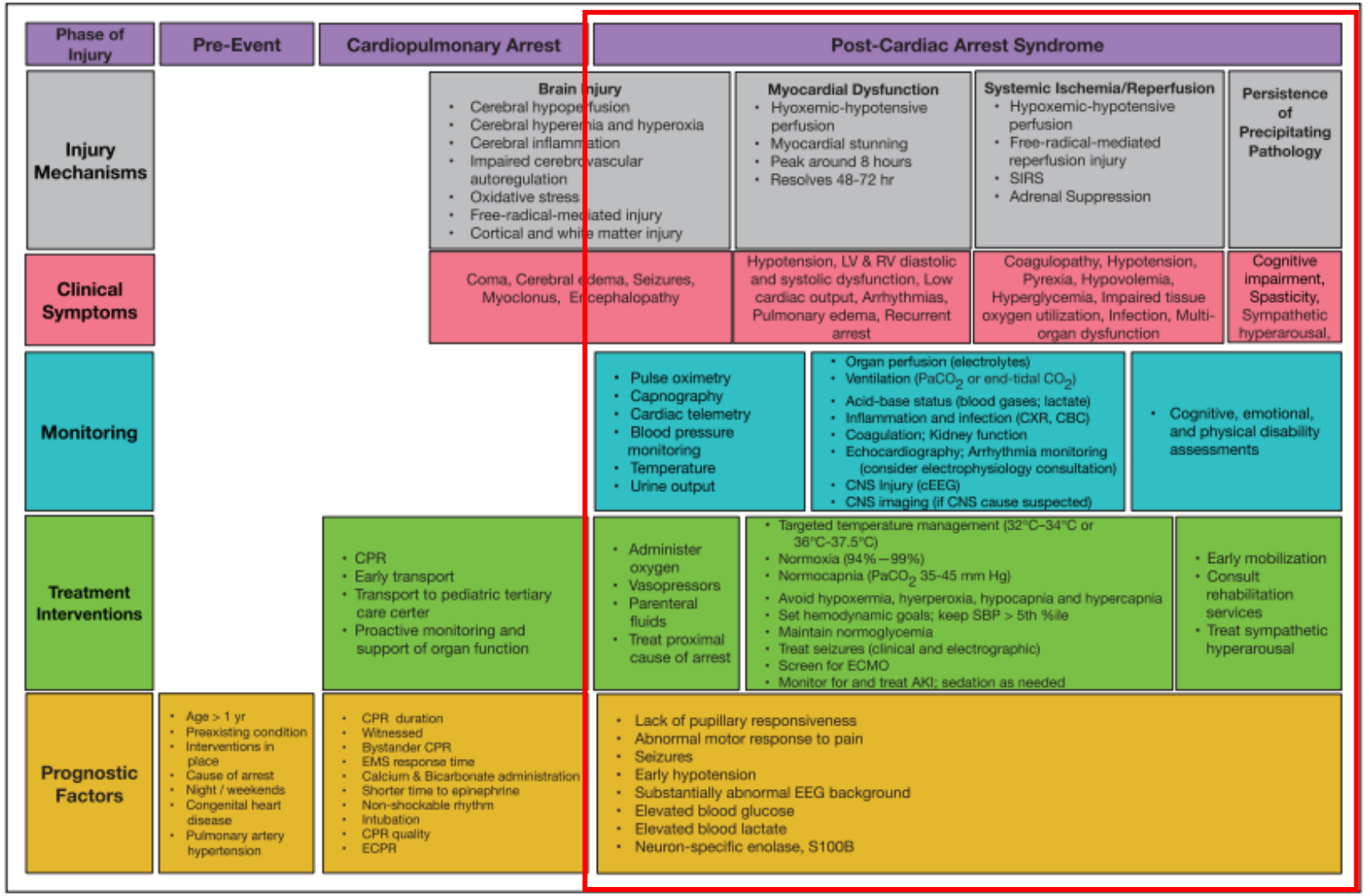
AHA SCIENTIFIC STATEMENT

Pediatric Post–Cardiac Arrest Care

https://www.shutterstock.com/image-photo/child-intensive-care-unit-after-heart-600246677

Topjian AA et al. Circulation. 2019;140:e194–e233. DOI: 10.1161/CIR.0000000000000697

Post Arrest Care



Phase of Injury	Pre-Event	Cardiopulmonary Arrest	Post-Cardiac Arrest Syndrome			
Injury Mechanisms		**Brain Injury** • Cerebral hypoperfusion • Cerebral hyperemia and hyperoxia • Cerebral inflammation • Impaired cerebrovascular autoregulation • Oxidative stress • Free-radical-mediated injury • Cortical and white matter injury	**Myocardial Dysfunction** • Hyoxemic-hypotensive perfusion • Myocardial stunning • Peak around 8 hours • Resolves 48-72 hr	**Systemic Ischemia/Reperfusion** • Hypoxemic-hypotensive perfusion • Free-radical-mediated reperfusion injury • SIRS • Adrenal Suppression	**Persistence of Precipitating Pathology**
Clinical Symptoms		Coma, Cerebral edema, Seizures, Myoclonus, Encephalopathy	Hypotension, LV & RV diastolic and systolic dysfunction, Low cardiac output, Arrhythmias, Pulmonary edema, Recurrent arrest	Coagulopathy, Hypotension, Pyrexia, Hypovolemia, Hyperglycemia, Impaired tissue oxygen utilization, Infection, Multi-organ dysfunction	Cognitive impairment, Spasticity, Sympathetic hyperarousal,
Monitoring			• Pulse oximetry • Capnography • Cardiac telemetry • Blood pressure monitoring • Temperature • Urine output	• Organ perfusion (electrolytes) • Ventilation ($PaCO_2$ or end-tidal CO_2) • Acid-base status (blood gases; lactate) • Inflammation and infection (CXR, CBC) • Coagulation; Kidney function • Echocardiography; Arrhythmia monitoring (consider electrophysiology consultation) • CNS Injury (cEEG) • CNS imaging (if CNS cause suspected)	• Cognitive, emotional, and physical disability assessments
Treatment Interventions		• CPR • Early transport • Transport to pediatric tertiary care certer • Proactive monitoring and support of organ function	• Administer oxygen • Vasopressors • Parenteral fluids • Treat proximal cause of arrest	• Targeted temperature management (32°C–34°C or 36°C-37.5°C) • Normoxia (94%—99%) • Normocapnia ($PaCO_2$ 35-45 mm Hg) • Avoid hypoxemia, hyerperoxia, hypocapnia and hypercapnia • Set hemodynamic goals; keep SBP > 5th %ile • Maintain normoglycemia • Treat seizures (clinical and electrographic) • Screen for ECMO • Monitor for and treat AKI; sedation as needed	• Early mobilization • Consult rehabilitation services • Treat sympathetic hyperarousal
Prognostic Factors	• Age > 1 yr • Preexisting condition • Interventions in place • Cause of arrest • Night / weekends • Congenital heart disease • Pulmonary artery hypertension	• CPR duration • Witnessed • Bystander CPR • EMS response time • Calcium & Bicarbonate administration • Shorter time to epinephrine • Non-shockable rhythm • Intubation • CPR quality • ECPR	• Lack of pupillary responsiveness • Abnormal motor response to pain • Seizures • Early hypotension • Substantially abnormal EEG background • Elevated blood glucose • Elevated blood lactate • Neuron-specific enolase, S100B		

Topjian AA et al. Circulation. 2019;140:e194–e233. DOI: 10.1161/CIR.0000000000000697

Priorities for Post Arrest Care

https://www.shutterstock.com/image-photo/pediatric-icu-ecg-monitor-on-foreground-138153896

- ❑Early hemodynamic optimization
- ❑Optimize ventilation and oxygenation
- ❑Treatment of persistent precipitating pathophysiology
- ❑Targeted temperature management
- ❑Control for seizures/neuro monitoring
- ❑Glucose control
- ❑Management of multi-organ dysfnction

Topjian AA et al. Circulation. 2019;140:e194–e233. DOI: 10.1161/CIR.0000000000000697

Paediatric targeted temperature management post cardiac arrest: A systematic review and meta-analysis

- Compared effectiveness of TTM at 32-36° to no TTM target or a different target
- Included 12 studies involving > 2000 patients

Conclusions:

- No statistical improvement in short or long term survival or long term survival with good neuro outcome
- Inconclusive evidence to either support or refute the use of TTM at 32–34°

Buick JE et al. *Resuscitation* 139 (2019) 65-75.
https://doi.org/10.1016/j.resuscitation.2019.03.038

Thermoregulation

AHA FOCUSED UPDATE

2019 American Heart Association Focused Update on Pediatric Advanced Life Support

An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Duff et al. Circulation. 2019

AHA SCIENTIFIC STATEMENT

Pediatric Post–Cardiac Arrest Care

A Scientific Statement From the American Heart Association

Topjian et al. Circulation. 2019

It is reasonable to use targeted temperature management of 32°C to 34°C followed by 36°C to 37.5°C, or to use targeted temperature management of 36°C to 37.5°C, for pediatric patients who remain comatose after resuscitation from out-of-hospital cardiac arrest or in-hospital cardiac arrest.

Resuscitation Improvement

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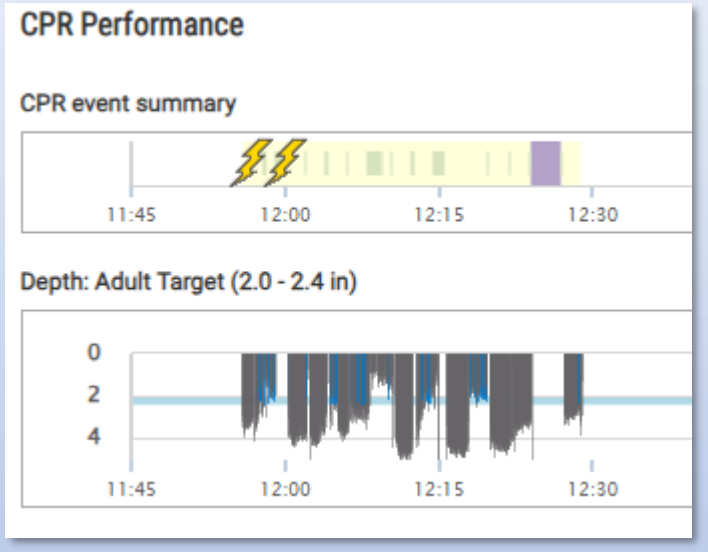
- Simulation/Training
- Hot/Cold Debriefs
- CPR Scorecards
- Team dynamics
- Prevention Bundles

CPR Data



AHA Comparison Chart:

AHA Data:	Gold Standard:	Our Team:
Initiation of chest compressions	<1 min	✓
Compressions rate	100-120 bpm	✓
Time to 1st Dose Epi	<5 min	✓
Correct Zoll pads placed?	ON	✓
Time to 1st Defibrillation	<2 min	N/A
ETCO2	ON	On and off ✓
	> 15 mmHg	
DBP	ON	
	<1 year: > 25 mmHg	N/A
	>1 year: > 30mmHg	
Time off chest	<10 seconds	
CPR coach designated role?	YES	✓

Monthly CPR Trend	Average compression fraction	Average preshock pause	Average postshock pause	Compression quality	Average manual depth	Average manual rate	Average release velocity
Targets	≥ 80%	≤ 5 secs	≤ 5 secs	≥ 60%	1.80 to 2.20 in	100 to 120 cpm	N/A
Oct 2023							
Nov 2023							
Dec 2023							
Jan 2024							
Feb 2024							
Mar 2024							
Apr 2024							
May 2024							
Jun 2024	77.11%	0.00	0.00	28.20%	1.63	108.91	234.47
Jul 2024	96.92%	0.00	0.00	23.75%	1.60	115.47	226.14
Aug 2024	85.20%	0.00	0.00	21.13%	1.49	114.62	241.30
Sep 2024	81.84%	0.00	0.00	8.12%	1.76	120.79	251.20
Oct 2024							

How do we get there?

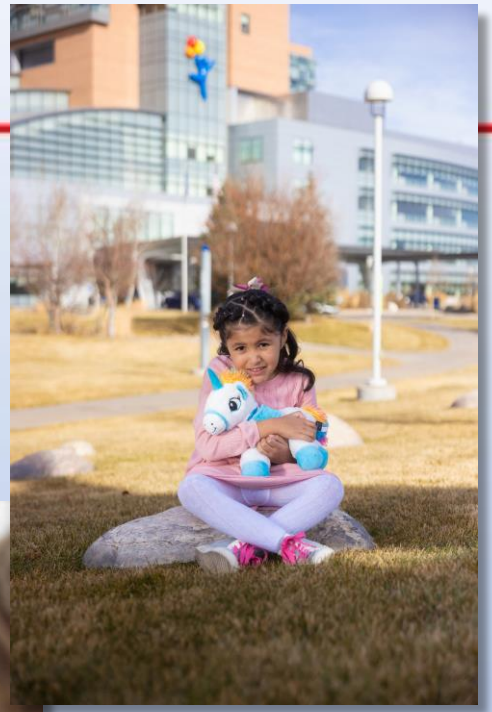
What Should We Measure?

- OHCA and IHCA Rate
- ROSC and Survival to discharge
- CPR Quality metrics
  - Chest compression fraction
  - Perishock pauses
  - Rate and depth targets
  - Team performance
  - Use of CPR coach
- Compliance with Post Arrest Care (for OHCA and IHCA)
- Survival with good neuro outcome

Final Thoughts

Final thoughts…….

- Outcomes have improved but there is much work to do
- Know the science and incorporate it into your event reviews and training
- Use feedback to guide provision of high quality CPR
- Post resuscitation care is critical in the quest to optimize outcomes
- Gather your team, know your data, share your data and make improvement goals



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