Pediatric CPR and Post Arrest Care

‘If if works for Otto, will it work for Bart?’
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PEDIATRIC ARREST DATA:

1. Survival after Out of Hospital Cardiac Arrest in Children
   J Am Heart Assoc. 2015; 4
   PMID: 26450118

2005-2013, review of 1980 pediatric out of hospital cardiac arrests
88.4% arrested at home
90% with non shockable rhythm
21.7% Infant (0-1)
48.1% Young Children (2-7)
13.9% Older children (8-12)
16.3% Teenager (13-17)

Survival to discharge 8.2%
There was no improvement in survival from 2005 to 2013.

The problem:
‘Successful CPR requires the rapid and effective implementation of infrequently used skills, in tense, high stakes situations.’

INTRA-ARREST:

EPINEPHRINE:

Adult studies show no overall survival benefit with standard, or high dose epinephrine during cardiac arrest. There is an increased rate of return of spontaneous circulation, and survival to 24h hours. There is NOT an increased rate of survival neurologically intact to discharge.

   PMID: 24642404
   14 studies are reviewed, (12,246 patients).
Epinephrine vs placebo, standard dose vs high dose epinephrine, standard dose epinephrine vs epinephrine and vasopressin, and standard dose epinephrine vs vasopressin.

Studies with higher doses of epinephrine improved ROSC, and survival to admission, but not survival to discharge neurologically intact.

PMID: 22436956
417,188 patients. Observational study (in Japan providers need to call medical control to give epinephrine). 15,030 received epinephrine, 402,158 did not.
ROSC: 18.5% vs 5.7% (epi vs no epi)
1 month survival 5.4% vs 4.7% (epi vs no epi)
Neuro intact survival 1.4% vs 2.2% (epi vs no epi)

Guidelines are softening:

2010 AHA guidelines:
It is reasonable to consider epinephrine every 3-5 minutes.

2015 AHA Guidelines:
Standard dose epinephrine may be reasonable for patients in cardiac arrest.

2015 PALS:
There are no pediatric studies showing effectiveness of any vasopressors in cardiac arrest.

4. Time to Epinephrine and survival after pediatric in hospital cardiac arrest.
JAMA 2015;314(8):802-810
PMID: 26305650
1558 pediatric patients, in hospital arrest, non shockable rhythms.
67% ROSC
47.8% Alive at 24 hours
31% survival to discharge with 15.6% favorable status
A delay in time to epinephrine administration was associated with decreased ROSC, 24 hour survival, and survival with good neurological function.
Each 1 minute delay in the administration of epinephrine:
ROSC 0.97
24h Survival 0.97
Survival with good neuro outcome 0.97
(adjusted relative risk per minute delay)

2015 AHA Guidelines:
'It is reasonable to administer epinephrine in pediatric arrest'
Class II evidence.
DRY CODES?:

Some providers run ‘dry codes’ in adults where no medications are given. The benefit is a decrease in task saturation, allowing better focus on compressions, and timing of defibrillation, along with less ‘unnecessary ROSC’ where short term survival is achieved without a good long term outcome.

EPINEPRINE DRIP INSTEAD OF BOLUSES:

The use of an epinephrine drip can potentially allow continued administration of epinephrine in either code doses, or more reasonable physiologic doses. Having a drip running allows for some cognitive offload, and can shift the focus toward better compressions. The epinephrine drip can also mitigate any post ROSC hypotension. In some cases after ROSC has been achieved following the use of ‘code dose epinephrine’ it can be followed by a precipitous drop in BP. Having a titratable epinephrine drip running can mitigate this. The CHEER trial evaluating the use of extracorporeal membrane oxygenation during cardiac arrest used an epinephrine drip at 0.5 mcg/kg/min for their patients while they were cannulating patients for intra-arrest ECMO.

5. Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial) Resus. 2015: 86;88-94
PMID: 25281189
Standard care versus intra-arrest ECMO for adult out of hospital cardiac arrest patients. While cannulating patients for ECMO during CPR an epinephrine drip was started at 0.5 mcg/kg/min, instead of using bolus / code doses of epinephrine. 0.5 mcg/kg/min equates to 250 mcg every 5 minutes, which is 25% of the epinephrine dose a 100kg patient would receive during a cardiac arrest.

PEDIATRIC INTRA-ARREST EPINEPHRINE DRIP DOSING:

A 20kg patient would receive 0.01mg/kg during a cardiac arrest. This is 0.2mg every 5 minutes. (40 mcg / min)
The equivalent drip rate would be 40 mcg/min, or 2 mcg/kg/min

CPR:

CCR: Cardio Cerebral Resuscitation.
Concept of optimizing compressions, and minimizing all other interruptions in the first few minutes of a cardiac arrest.
Immediate CPR
No Post shock rhythm or pulse checks
No airway interventions other than a non rebreather and oral airway.
In a witnessed arrest, there were no assisted ventilations or intubation attempts until ROSC or 3 cycles of CPR had been completed.

PMID: 16564776
Before :after comparison of cardiac arrest survival after introduction of CCR.
In patients with shockable rhythms neuro intact survival improved from 15% to 48%

PMID: 19414637
Before : After comparison.
Limited CPR interruption, increased compression to ventilation ratio.
De-emphasizing / delaying intubation.
Delivered compressions before first shock.
In arrest of presumed cardiac cause survival improved from 7.5% to 13.9%
In patients with shockable rhythms ROSC improved from 37.8% to 59.6%

Pediatric arrests are more likely to be due to respiratory compromise, so delaying airway interventions may not work in this setting.
PALS algorithm goes through 1 -2 cycles of CPR prior to suggesting ‘consider advanced airway’.
CCR approach provides continued attention to quality, minimally interrupted compressions.

PERI-SHOCK PAUSE:

Most pediatric arrests will not have shockable rhythms. If there is a shockable rhythm we need to be aware of issues surrounding the peri-shock pause.

Peri-shock pause is the total time without chest compressions while a shock is delivered. It includes the pre-shock pause, and the post shock pause.

PMID: 24513129
2006 patients with shockable rhythms
Median pre-shock pause 15 seconds
Median post-shock pause 6 seconds
Median peri-shock pause 22 seconds

Odds of survival to Discharge IMPROVE with a shorter pre, and peri-shock pause.
Pre shock pause <10 seconds, vs >20 seconds: 1.52
Peri-shock pause <20 seconds, vs >40 seconds: 1.82
No difference with post shock pause length.

PEDIATRIC IMPLICATIONS:
There will be fewer opportunities for shock delivery in pediatric arrests, however applying this strategy of minimizing CPR interruptions to other interventions such as intubation is likely to improve outcomes.
‘If you cannot intubate without stopping compressions, learn how!’

CPR QUALITY:

PMID: 20226582
42 subjects performed 4 different cycles of CPR (2 min per cycle)
Assessed for rate, depth.
Average rate: 110 / min
High quality compression rate (based on depth) 9.4%

END TIDAL CO2:

‘ETCO2 is the smoke that rises of the metabolic fire.’ Ray Fowles, MD

PMID: 24732917
2kg pigs, 20 per group.
Group one: Optimized CPR
Real time video feedback for rate, depth, with verbal and visual prompts.
Group two: ETCO2 based CPR
Only visible metric was ETCO2 value.
ROSC rates were statistically similar (65% vs 70%) with higher ETCO2 levels in the ETCO2 group (28.5 vs 22.7) and higher MAP’s in the ETCO2 group.

2015 AHA Guidelines:
ETCO2 monitoring may be considered to evaluate quality of chest compressions.
Specific values to guide therapy have not been established.
A goal of >15mmHg is reasonable.

PULSE CHECKS:

PMID: 9715777
Healthy 30 year old male volunteer.
ICU and ED staff were timed to locate carotid pulse.
43% took longer than 5 seconds, 4% took longer than 10 seconds.

PMID: 9025126
Timed first responders to assess for the presence of a carotid pulse in a patient undergoing coronary artery bypass surgery.
Pulses were assessed during spontaneous circulation, and during non pulsatile cardiopulmonary bypass.
BLS trained laypersons vs EMT's vs Paramedics.
10% did not recognize pulselessness
45% did not recognize pulse with a BP of 80 mmHg
2% identified pulselessness in <10 sec
15% produced correct diagnosis in <10 sec

13. Reliability of pulse palpation by healthcare personnel to diagnose pediatric cardiac arrest. Resuscitation 2009 Jan;80(1):61-4
PMID: 18992985
Pediatric ECMO / LVAD patients at various stages of recovery.
209 ICU MD’s and RN's assessed presence of pulse in patients on LVAD’s or VA ECMO.
Overall accuracy 78%
CPR inappropriately withheld: 14%
CPR inappropriately given: 36%

END TIDAL CO2 TO ASSESS FOR ROSC:
A large bump in ETCO2 can signify an increase in cardiac output, and suggest ROSC.

PMID: 19570645
108 patients with cardiac arrest and continuous ETCO2 monitoring. Age 0.5 – 90 years.
59 with ROSC, 49 without ROSC.
ETCO2 pre vs post ROSC: 26.65 vs 36.60 mmHg
STOPPING CPR:

There are no good guidelines.

PMID: 9233867
150 consecutive cardiac arrests.
When ETCO2 is < 10 mmHg at 20 min, likelihood of neuro-intact survival is extremely low.
ETCO2 < 10 mmHg at 20 min + non survivable
Sens, Spec, Positive predictive value, Negative predictive value all 100%

RULE OF 10’s:
Bump of 10 mmHg: ROSC
ETCO2 > 10 mmHg at 20 min: stop.

2015 AHA Guidelines:
No significant factor predicts outcome with significant accuracy to recommend termination.
Age <1
In Hospital arrest
Non shockable rhythm

POST ARREST CARE:

TARGETTED TEMPERATURE MANAGEMENT:

16. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest.(HACA)
NEJM 2002 Feb 21;346(8):549-56
PMID: 11856793
273 Patients, 33C vs usual care.
41% vs 55% mortality NNT 7

17. Treatment of comatose survivors of out of hospital cardiac arrest with induced hypothermia.(Bernard)
NEJM 2002 Feb 21;346(8):557-63
PMID: 11856794
77 patients. 33C vs usual care
49% vs 26% favourable outcome. NNT 4.5

Combined NNT 6
18. Targeted temperature management at 33 C versus 36 C after cardiac arrest.
NEJM 2013, dec 5;369(23):2197-206
PMID: 24237006
33C vs 36C
973 patients.
48% vs 50% mortality
Fever avoidance is the current standard, with some centers staying with 33C.

PEDIATRIC TARGETTED TEMPERATURE MANAGEMENT:

NEJM 372;20 May 14, 2015 1898-908
PMID: 25913022
260 patients
CPR >2min, unconscious post ROSC
33C vs 36.8C (therapeutic normothermia)
No difference in 12 month survival with VABS-II > 70
Recommendations:
Avoid fever

OXYGEN:

Hyperoxia may be harmful in the post arrest setting.

20. Relationship between supranormal oxygen tension and outcome after resuscitation from cardiac arrest. Circulation 2011; 123: 2717-2722
PMID: 21606393
4459 patients
54% mortality
Dose dependent association between supra-normal oxygen tension and in-hospital death.
Every 100 mmHg increase in PaO2 associated with 24% increased risk of death.

RECOMMENDATION:
HAVE A MEASURABLE O2 SAT (94-99%) NOT 100%
**PEDIATRIC POST ARREST OXYGEN LEVELS:**

PALS recommends PaO2 >60 and <300mmHg

PMID: 22723307
Severe hypoxia, and to a lesser extent, hyperoxia are associated with an increased risk of death after PICU admission after cardiac arrest. PaO2 >600mmHg gives an OR of 1.25 (1.17-1.37) for Death.

PMID: 25576438
200 patients, aged >28 days, mean 2.6 years.
ABG at 3 time intervals, and 3 cut-off values
42% survival to discharge, 29% managed with TTM
Higher cumulative PaO2 level associated with lower in hospital mortality.

**POST ARREST BP GOALS:**

Adults:
AHA Guidelines
MAP >65mmHg
SBP >90mmHg
(some authors suggest MAP>75mmHg)

Pediatric BP goals:
2015 AHA guidelines
NO studies looking at specific post ROSC pressor.
Fluids +/- Pressors for goal SBP >5th percentile

23. Early post resuscitation hypotension is associated with increased mortality following pediatric cardiac arrest. Critical Care Med. 2014;42:1518-23
PMID: 24561563
Increased risk of death for SBP <5th percentile post ROSC (53% vs 41%)
Increased odds of in-hospital death: 1.71 (95% CI: 1.02-2.89 p=0.042)
INTERVENTIONS THAT HELP:

ETCO2 for compression quality, evidence of ROSC, and justification for termination
Compressions
Epinephrine
Post ROSC fever avoidance

INTERVENTIONS THAT DO NOT HELP:

Pulse checks
Peri-shock pauses (and stopping compressions to intubate)
Hyper-Hyperoxia

EXTRA 10 MINUTES IN THE ROOM:

Sara Gray MD (@emicucanada) gave a great talk at the SMACC conference in June 2015.
She recommended spending an extra 10 minutes in the room after ROSC, and after any intubation to ‘sweat the small stuff’
Ensure the ETT is at the right depth, check the cuff, re-check the vent settings, dial down the FiO2, check the ETCO2, ensure appropriate post intubation analgesia and sedation, recheck lines and drips.

‘it doesn’t matter how good you are at doing the fancy stuff, if you are not EXCELLENT at doing the easy stuff!’