Learning Objectives

- Identify 2015 PALS Science Update recommendations and changes (ILCOR)
- Describe the rationale for the PALS 2015 Science Update
- Review the aspects of post-resuscitation care

Immediate Recognition and Activation of EMS

- 2010: A very methodical process was emphasized
  - Check for responsiveness
  - Check for no breathing or no normal breathing
  - Call for help
  - Check for pulse
- 2015: A more simultaneous and realistic approach
  - Call for nearby help
  - Assess for breathing and pulse simultaneously
  - Activate EMS or call for backup

Recommendations

- Pre-Arrest Care
- Intra-Arrest Care
- Post-Arrest Care

Pre-Arrest Care

- Effectiveness of medical emergency teams or rapid response teams to improve outcomes
- Observational data –contradictory
- No consistent decreased incidence of cardiac and/or respiratory arrest outside of the ICU
- Pediatric RRT team systems may be considered in facilities where children with high-risk illnesses
Checking Breathing and Pulse

- Simultaneous breathing and pulse check in less than 10 sec

Intra-Arrest Care

Compression RATE AND Depth

- Chest Compression rate 100-120 per minute
- Depth: At least 1/3 the AP diameter of the chest
  - Infants: approximately 1.5” (4cm)
  - Children: approximately 2” (5 cm)
  - Class IIa, LOE C-LD.
- Adolescents (beyond puberty):
  - at least 2” (5 cm), but no greater than 2.4” (6 cm)
  - Class 1, LOE C-LD.

Compression depth

Real-time Feedback Improving Pediatric CPR Quality

- The consensus of the writing group is that the use of feedback devices likely help the rescuer optimize adequate chest compression rate and depth, and we suggest their use when available (Class IIb, LOE C-EO)

Feedback Device
**EFFECT of MONITORING**

- Conventional CPR with chest compressions and rescue breaths should be provided for pediatric cardiac arrests (Class I, LOE B-NR)
- Because compression-only CPR is effective in patients with a primary cardiac event, if rescuers are unwilling or unable to deliver breaths, we recommend rescuers perform compression-only CPR for infants and children in cardiac arrest (Class I, LOE B-NR).

**Ventilation during CPR with advanced airway**
- Deliver 1 breath every 6 sec (10 breaths/ min) while continuous chest compressions performed
- Single rate for all age groups for ease of remembering and performing

**Fluid Resuscitation in Septic Shock**
- Initial fluid bolus of 20 mL/kg to infants, children
  - Severe sepsis (Class llb, LOE C-R)
  - Severe malaria and Dengue (Class llb, LOE B-R)
  - No benefit to fluid restriction, crystalloid or non-crystalloid
- Providers should reassess the patient after every fluid bolus (Class I, LOE C-EO)
- Resource limited settings and limited access to critical care interventions
- Bolus intravenous fluids should be undertaken with extreme caution because it may be harmful (Class llb, LOE B-R)

**Atropine for Endotracheal Intubations**
- No evidence to support routine use of atropine as premedication to prevent bradycardia in emergency pediatric intubations
- May be considered in situations of increased risk
- No minimum dosing (0.02 mg/kg)
Prearrest Care of Infants and Children With Dilated Cardiomyopathy or Myocarditis

- No literature was identified evaluating best prearrest management strategies for infants and children with dilated cardiomyopathy or myocarditis
- VA ECMO use may be considered in patients with acute fulminant myocarditis who are at high risk of imminent cardiac arrest

Extracorporeal CPR for In-Hospital Pediatric Cardiac Arrest

- Pediatric IHCA has shown no overall benefit to the use of CPR with ECMO (ECPR) compared to CPR without ECMO
- Pediatric IHCA registry- improved survival to hospital discharge with the use of ECPR in pts with surgical cardiac diagnoses
  - Long-term survival reported >50 min of CPR
- When ECPR is used during cardiac arrest, outcome for children with underlying cardiac disease is better than for those with noncardiac disease.

Invasive Hemodynamic Monitoring During CPR

- Two randomized controlled animal studies:
  - likelihood of ROSC and survival to completion of experiment with invasive hemodynamic monitoring
- With invasive hemodynamic monitoring in place,
  - Reasonable to use blood pressure to guide CPR quality

End-Tidal CO2 Monitoring to Guide CPR Quality

- Past recommendations: if ETCO2 < 15 mm Hg, efforts should focus on improving CPR quality
  - Improving chest compressions and
  - Avoiding excessive ventilation
- No pediatric evidence that ETCO2 monitoring improves outcomes from cardiac arrest

Antiarrhythmic Medications

- Amiodarone or lidocaine is equally acceptable for treatment of shock-refractory VF or pulseless VT in children
- Compared to amiodarone, lidocaine was associated with higher rates of ROSC and 24-hour survival
- Neither Lidocaine nor amiodarone administration was associated with improved survival to hospital discharge
Amiodarone or Lidocaine for pVT/VF

- For shock-refractory VF or pVT, either amiodarone or lidocaine may be used (Class IIb, LOE C-LD).

<table>
<thead>
<tr>
<th>Lidocaine Use</th>
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<tbody>
<tr>
<td>Adjusted OR for ROSC</td>
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<tr>
<td>2.02</td>
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</tbody>
</table>

Because there was no univariate association between amiodarone and any of the outcomes of interest, amiodarone was excluded from the final multivariate analysis. Total patients = 889 Amiodarone = 171 Lidocaine = 285

Valdes, Resuscitation 2014

Intra-arrest Prognostication

- Multiple variables should be used when attempting to prognosticate outcomes during cardiac arrest (Class I, LOE C-LD).

- Although there are factors associated with better or worse outcomes, no single factor studied predicts outcome with sufficient accuracy to recommend termination or continuation of CPR.

Valdes, Resuscitation 2014

Elements of a High-Q(uality) Resuscitation Program

- Data Collection
- Feedback (individual & organizational)
- Training / Retraining
- Reporting / Benchmarking

A Remedy for Skills Deterioration?

- Minimal Competence
- Ideal Performance

Time to Excellence Improved

- Time to achieve chest compression skill success* per group
  - ≥ 2 times per month
  - < 2 times per month

Post-Arrest Care Updates and Post Resuscitation Care
**Pre-Arrest**
- Cardiac Arrest
- CPR

**Post-Arrest stabilization**
- No Flow
- Low Flow
- Low, Normal or High Flow

**PREVENTION**
- Rapid Recognition
- Call for Help
- Response Team
- Oxygen/Ventilation

**PROTECTION**
- Prompt CC
- Defibrillate if VF

**PRESERVATION**
- Blood pressure
- Oxygen titration
- Ventilation (CO2) titration
- Seizure Detection and Control
- Arrhythmia control
- Glucose control
- Cardiac Catheterization (PCI)

**RESUSCITATION**
- Push hard, Push Fast
- Full recoil
- Assist ventilation?

**REGENERATION**
- Targeted Temperature management
- Blood pressure
- Oxygen titration
- Ventilation (CO2)

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### Targeted Temperature Management
- For children who are comatose in the first several days after cardiac arrest (in-hospital or out-hospital), temperature should be monitored continuously and fever should be treated aggressively.

- For comatose children resuscitated from OHCA, maintain either 5 days of normothermia (36°C to 37°C) or 2 day of initial continuous hypothermia (32°C to 34°C) followed with 3 days of normothermia.

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### Questions about hypothermia
1. **Who should be cooled?**
2. **When to cool?**
3. **How to cool?**
4. **How deep to cool?**
5. **How long to keep cool?**
6. **How to rewarm?**
Post–Cardiac Arrest Fluids and Inotropes

- Worse survival to hospital discharge when children were exposed to post-ROSC hypotension
- Post-ROSC hypotension (SBP <5% for age) after IHCA with lower likelihood of survival to discharge with favorable neurologic outcome
- Fluids and/or vasoactive drugs be used to maintain a > SBP <5% for age

Post-CA Hypotension

- Project IMPACT: 8736 patients
- Hypotension (ICU SBP<90 within 1 hr): 47%
  - Mortality
    - Hypotension 65%
    - No hypotension 37%
    - Odds of death 2.7 (95% CI: 2.5-3.0)

Pediatric Post-Arrest ICU Hypotension

- PECARN: 383 children
- Hypotension (SBP<5%ile within 6 hr): 56%
  - Mortality
    - Hypotension 53%
    - No hypotension 41%
    - Odds of death: 1.71 (95% CI: 1.02, 2.89)

LV Systolic Function Following OHCA

- 58 patients admitted to CHOP PICU
- Echocardiogram within 24 hours of ROSC
- Decreased function vs Normal Function
- Only SVO2< 60 differentiated ECHO findings
  - After controlling for VF and vasopressor scores, patients with decreased function had 13.7 times higher odds or death
Post–Cardiac Arrest Oxygenation

- No association between elevated PaO2 and outcome (pediatric IHCA and OHCA survivors)
- 1427 pediatric IHCA and OHCA victims: Normoxemia (>PaO2 60 mmHg and <300 mm Hg) vs. hyperoxemia (PaO2 >300 mm Hg) after ROSC
  - Improved survival to pediatric ICU discharge in normoxemia group
  - Target normoxemia after ROSC

Pediatric Post-CA Hyperoxia

- 195 pediatric cardiac arrests: survive > 6 h
  - 54% hyperoxia, 22% hypoxia
    - No relationship with survival
    - Statler, CCM 2013
- 74 ped CA: 51% hyperoxia; 14% hypoxia
  - No relationship with survival
  - Guerra-Wallace, PCCM 2013
- PICANET: n= 1875 : 11% hyperoxia, 24% hypoxia
  - Odds of death 1.25 (95% CI: 1.17-1.37)
  - Ferguson, Circulation 2012

Post–Cardiac Arrest PaCO2

- No association between hypercapnia (PaCO2 > 50 mm Hg) or hypocapnia (PaCO2 <30 mm Hg) and outcome
- Observational study of pediatric IHCA, hypercapnia (PaCO> 50 mm Hg) was associated with worse survival to hospital discharge
- Target a PaCO2 after ROSC (appropriate to the specific patient condition)

EEG Monitoring

- Observational data showed that a continuous and reactive EEG tracing EEG (first 7 days) after cardiac arrest was associated with a significantly higher likelihood of good neurologic outcome
- Discontinuous or isoelectric tracing was associated with a poorer neurologic outcome
- EEG in first 7 days may be used for prognosis

Post Resuscitation Use of EEG for Prognosis

- Electroclinical Seizures
  - Electrographic Seizures
  - Clinical “Seizures”
Non-convulsive Seizures are Associated with Worse Outcome in Adults

- In critically ill adults, seizure duration and delay in diagnosis are associated with higher mortality
  - Young, Neurology, 1996
- In an adult ICU, non-convulsive seizures were associated with death or severe disability at hospital discharge
  - Oddo, CCM 2009; Carrera, Arch Neurol, 2008
- Following adult out-of-hospital cardiac arrest, NCSE is associated with worse neurologic outcome
  - Fugate, 2010; Krumholz 1988; Wennervita, CCM, 2009; Rosselli, 2009

Pediatric Post-Arrest Seizures

- 19 children treated with hypothermia
  - Seizures 47%
  - Status Epilepticus 32%
- Severely abnormal background
  - 100% PPV for seizures
- Electrographic seizures
  - 78% PPV for poor outcome

Electrographic Status Epilepticus is Associated with Worse Outcomes

<table>
<thead>
<tr>
<th>MORTALITY</th>
<th>OR (95% CI)</th>
<th>▲ PCPC</th>
<th>OR (95% CI)</th>
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<tbody>
<tr>
<td>No Seizures</td>
<td>ref</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Electrographic Seizures</td>
<td>1.3 (0.3, 5.1)</td>
<td>p=0.74</td>
<td>1.2 (0.4, 3.9)</td>
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<tr>
<td>Electrographic Status Epilepticus</td>
<td>5.1 (1.4, 18)</td>
<td>p=0.01</td>
<td>17.3 (3.7, 80)</td>
</tr>
</tbody>
</table>

Controlled for age, sex, acute etiology, EEG background, prior neurodevelopmental abnormality and EEG monitoring indication

Topjian, CCM, 2013

Predictive Factors After Cardiac Arrest

- Four observational studies supported the use of pupillary reactivity at 12 to 24 hours after cardiac arrest in predicting survival to discharge
  - Reactive pupils 24 hours after cardiac arrest associated with improved survival at 180 days with favorable neurologic outcome
- Lower neuron-specific enolase, S100B, serum lactate levels
- Should consider multiple factors when predicting outcomes in infants and children who achieve ROSC after cardiac arrest

PALS Recommendations and Changes

- Chest compression rate and depth
- Ventilation during CPR with an advanced airway
- Recommendations for fluid resuscitation
- Atropine for endotracheal intubation
- Antiarrhythmic medications for shock refractory VF or pulseless VT
- Targeted temperature management
Mobile app alerts CPR-trained bystanders to someone nearby having a sudden cardiac arrest that may require CPR
- Activated by the local public safety communications center simultaneous with the dispatch of local fire and EMS resources

Thank You!

References