Pediatric Cardiac Emergencies

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https://www.youtube.com/watch?v=sff0_njY_iQ
Overview

• Definition of Cardiac Arrest:
  • Cessation of cardiac mechanical activity, determined by unresponsiveness, apnea, and lack of evidence of an effective circulation.

Overview

• Cardiac arrest in infants and children does not usually result from a primary cardiac cause.

• Asphyxial arrest:
  • Cardiac arrest is the terminal result of progressive respiratory failure or shock
  • Beings with variable period of systemic hypoxemia, hypercapnia, and acidosis
  • Progresses to bradycardia, hypotension and asystole
Overview

Examples of Asphyxial arrest

- Drowning
- Smoke inhalation
- Foreign body obstruction
- Hanging
- Seizures
- Toxin ingestion
- Central apnea
- Acute respiratory illness
- SIDS

Overview

Survival from in-hospital cardiac arrest in infants and children:

- 1980s approximately 9%
- 2000 approximately 17%
- 2006 approximately 27%
- 2009 approximately 39%
Overview

• In contrast, overall survival to discharge from out-of-hospital cardiac arrest (OHCA) in infants and children:

  • Remains about 6% (3% for infants and 9% for children and adolescents) over the last 20 years.

  • More recent published data from Resuscitation Outcomes Consortium (registry of 11 US and Canadian emergency medical systems) demonstrated 8.5% survival to hospital discharge.

  • Survival rate with a shockable initial rhythm (pulseless VT or VF) is approximately 20%, with a >70% favorable neurologic outcome.

Overview

• Ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) is the initial cardiac rhythm in approximately 5 – 15% of pediatric in-hospital and out-of-hospital cardiac arrests

  • Incidence of VF / pulseless VT cardiac arrest rises with age.

  • VF eventually deteriorates into asystole over time.

  • Reported prevalence of VF depends on the aggressiveness and timing of monitoring.
Pediatric Cardiac Arrest

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<th>INTERVENTIONS</th>
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<td>Optimize community education regarding child safety</td>
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<td>Optimize patient monitoring and rapid emergency response</td>
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<td>Recognize and treat respiratory failure and/or shock to prevent cardiac arrest</td>
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<td>Arrest (no-flow) phase</td>
<td>Minimize interval to BLS and ALS (organized response)</td>
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<tr>
<td>(preserve)</td>
<td>Minimize interval to defibrillation, when indicated</td>
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<td>Low-flow (CPR) phase</td>
<td>“Push hard, push fast”</td>
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<tr>
<td>(resuscitate)</td>
<td>Allow full-chest recoil</td>
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<td></td>
<td>Minimize interruptions in compressions</td>
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<td>Avoid overventilation</td>
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<td>Titrte CPR to optimize myocardial blood flow (coronary perfusion pressures and exhaled CO2)</td>
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<td>Consider adjuncts to improve vital organ perfusion during CPR</td>
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<td>Consider ECMO if standard CPR/IMs not promptly successful</td>
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<td>Postresuscitation phase</td>
<td>Optimize cardiac output and cerebral perfusion</td>
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<td>Short-term rehabilitation</td>
<td>Treat arrhythmias, if indicated</td>
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<td>Avoid hypervolemia, hyperthermia, hyperventilation</td>
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<td>Consider mild postresuscitation systemic hyperthermia</td>
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<td>Debrief to improve future responses to emergencies</td>
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<td>Early intervention with occupational and physical therapy</td>
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<td>Long-term rehabilitation</td>
<td>Bioengineering and technology interface</td>
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<td>(regenerate)</td>
<td>Possible future role for stem cell transplantation</td>
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BLS: basic life support; ALS, advanced life support; ECMO: extracorporeal membrane oxygenation; CPR, cardiopulmonary resuscitation.

Pediatric OHCA

- Chain of survival from American Heart Association (AHA) for out-of-hospital pediatric cardiac arrest:
  - Prevention
    - Education
    - Recognition
  - Early CPR
    - Only 1/3 to 1/2 of children are provided with bystander CPR
    - When not provided with bystander CPR, no-flow period is prolonged
  - Call for Help
    - Typically 6-15 minutes before emergency medical services personnel arrive.
  - Rapid implementation of pediatric advance life support (PALS)
  - Aggressive postresuscitation care
Early Bystander CPR

• Role of Hands-Only CPR
  
  • Children with sudden collapse cardiac arrests of PRESUMED CARDIAC ETIOLOGY, hands-only CPR is as effective as chest compression plus rescue breathing.
    
    • Reservoir of oxygen in the lungs is adequate to oxygenate blood perfusing through the lungs during low-flow state of CPR for 5-15 minutes.
    
    • Gas exchange occurs with gasping during CPR
    
    • Gas enters the lungs during relaxation phase of compression because of negative pressure generated with chest recoil.

Early Bystander CPR

• Most pediatric OHCAs result from an asphyxia event. Therefore, lungs are depleted of oxygen by the time cardiac arrest occurs.

• Gasping during CPR may be less frequent when there is profoundly hypoxemic perfusion to the brain.

• Providing some oxygen with rescue breathing substantially improves outcomes from asphyxia cardiac arrests.
Early Bystander CPR

- **Appreciating the difference** between a sudden collapse cardiac arrest and acute asphyxia event is a complex task.
  - Since most pediatric OHCAs are secondary to acute asphyxia, chest compression plus rescue breathing is the recommended approach for pediatric OHCAs.

- **Sequence:**
  - C-A-B (compressions – airway – breathing)
  - A-B-C (airway – breathing – compressions)

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Early Bystander CPR

- **C-A-B**
  - Simplification in teaching across pediatric and adult age groups
  - Decrease time to initiation of chest compression
  - Reduces “no blood flow” time

- **A-B-C**
  - Recognizes preponderance of asphyxial etiologies in pediatric cardiac arrest
  - Emphasis on early ventilation
Defibrillation

• Goal: Return of an organized electrical rhythm with pulse

• Termination of fibrillation can result in asystole, PEA, or a perfusing rhythm.

• Prompt defibrillation provided soon after induction of VF in a cardiac catheterization laboratory, resulted in successful defibrillation and survival approaching 100%.

Defibrillation - AEDs

• When automated external defibrillators (AED) are used within 3 minutes of adult-witnessed VF, long-term survival can occur in >70%.

• Mortality increased by about 10% per minute of delay to defibrillation.
AEDs

- Lack of shock delivery for pediatric VF is ultimately 100% lethal.
- Adult defibrillation doses are preferable to no defibrillation.
- Case report suggests that an adult AED dose could save a life of a 3-year-old child in VF.
  - Defibrillated with a biphasic shock of 150 (9J/kg).
  - He survived without any apparent adverse effects.
  - No elevation in serum creatine kinase or cardiac troponin I
  - Normal postresuscitation ventricular function on echocardiogram.

AEDs

- Initial concerns:
  Babies and small children with sinus tachycardia or supraventricular tachycardia can have high heart rates that might be misinterpreted as “shockable” by AEDs with diagnostic programs developed for adult arrhythmias.

- Studies regarding rhythm-analysis programs from modern AEDs:
  - Established that the algorithms were specific for detecting VF and VT.
  - The algorithm did not misinterpret other rhythms as VF or VT and therefore did not recommend shocking a “nonshockable” rhythm.
Commotio Cordis

- Low-energy blunt chest trauma resulting in sudden cardiac arrest.

- 2nd leading cause of death in young athletes occurring typically in males.

Timing and location of chest wall impact determine the development of VF.

- Timing: Critical 15-20 millisecond window of cardiac repolarization.

- Location: Impact has to be directly over the cardiac silhouette to induce VF.
Commotio Cordis

Commotio Cordis

Figure 3. Pathophysiology of Commotio Cordis

Commotio Cordis may involve ball or puck or may be inflicted through bodily contact. The location of the blow on the chest and the timing relative to the cardiac cycle are the primary determinants of commotio cordis. Other factors that may contribute to the risk of an event include the density, size, and orientation of the projectile and the shape of the thorax; younger people are the most vulnerable because of ill-fitting, less developed rib cage and musculature.

Advances in Arrhythmia and Electrophysiology

Commotio Cordis

Figure 3. The confluence of variables and a proposed mechanism necessary for commotio cordis to occur. Important impact-object variables are shape, hardness, diameter, and velocity. Human characteristics are the position of the chest wall, impact timing, location and orientation of ribs, and individual susceptibility. Likely involved in ion channels involved in repolarization. LV indicates left ventricle. Reprinted from the Journal of Cardiovascular Electrophysiology, with permission.
Incidence

- Absence of systematic and mandatory reporting
  - Precise incidence of commotion cordis is unknown
- Basis of National Commotio Cordis Registry in Minneapolis
  - Among the most frequent cardiovascular causes of sudden death in young athletes
  - Undoubtedly underreported, but recognized with increasing frequency.

Epidemiology

- Predilection for children and adolescents
  - Mean age, 15±9 years
  - Range, 6 weeks to 50 years
- 26% of victims < 10 years of age
- 9% ≥ 25 years of age
- Most were boys or men (95%) and are white (78%)
Outcome

• Commotio cordis usually, but not invariably, fatal

• Death often associated with failure of bystanders to appreciate the life-threatening nature of collapse and to initiate appropriately aggressive and timely measures of resuscitation.

Primary Prevention

• Commercially available chest protector have proven inadequate in prevention of commotion cordis.
  - Protector may move when arms are raised
  - Composite material does not adequately attenuate blow

• Flow diagram (Panel D): almost 1/3 of athletes who died were wearing a chest barrier.
Secondary prevention

- AEDs have substantial life-saving capability.
- Disseminate widely at youth sporting events and recreational settings.
- Public health strategy that incorporates a plan for making AEDs widely available.
- Effectively terminated ventricular fibrillation in animal models of commotion cordis.

CNN – Teen comes back to life during game (2/2/2016)

References


