The American Heart Association Guidelines Including Pediatric Resuscitation

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Objectives

On completion of this lesson, you should be able to:

1. List the correct sequence of steps and explain the rationale for the performance of cardiopulmonary resuscitation according to the new basic life support guidelines.

2. Describe the 2010 guidelines for chest compressions and discuss how they differ from the 2005 guidelines.

3. Explain the differences in airway and breathing assessment in the 2010 guidelines compared to the previous guidelines and the physiology and research behind the changes.

4. Discuss the recommendations for automated external defibrillator use in infants and children and explain the science behind the recommendations.

5. State the recommended defibrillation doses for infants and children and why these dosages are suggested.

6. Describe the specific recommendations (including capnography, therapeutic hyperthermia, avoiding hyperoxia) for post-arrest care.

7. Explain the pharmacology recommendations in the 2010 guidelines and how they differ from the 2005 guidelines.

From the EM Model

3.0 Cardiovascular Disorders
   3.1 Cardiopulmonary Arrest

Case Presentations

Case One

EMS first responders arrive at the home of a 2-month-old female infant who is found unresponsive in her crib. She was born at full term, had no neonatal problems, has no known medical illnesses, is on no medicines, and has no allergies. There are no signs of trauma. Her weight is 4 kg.

The EMT checks the infant for responsiveness and breathing and then asks the parent to go get both of his partners (who are in the ambulance) and to bring the automated external defibrillator (AED). The infant is not responsive and is not breathing, so the EMT begins chest compressions immediately at a rate of about 100/min, and at a depth of approximately 1½ inches (4 mm).

The EMT does chest compressions for 2 minutes, while his partners set up and administer supplemental oxygen and insert an intravenous line without interrupting the compressions. The EMTs do not have a manual defibrillator and their AED does not have a pediatric dose attenuator system, so they use the available AED. The AED advises a shock, so a shock is given.

After another 2 minutes of chest compressions, the rhythm is checked and it is a shockable rhythm, so another shock is given by the AED. CPR with chest compressions is continued for 2 minutes and intravenous epinephrine (0.01 mg/kg × 4 kg = 0.04 mg) is given every 3 to 5 minutes. The next rhythm check recommends a shock so this is done, chest compressions are restarted, and amiodarone (5 mg/kg × 4 kg = 20 mg IV) is given. After another 2 minutes of chest compressions, the AED does not advise a shock and...
the monitor indicates asystole. CPR with chest compressions is resumed, epinephrine is given every 3 to 5 minutes, and reversible causes of the patient’s condition are considered as the patient is transported to the emergency department.

■ Case Two

A 6-year-old boy arrives with a chief complaint of trouble breathing. His past medical history is negative. He is on no medicine and has no allergies. He has had a “cold” with a fever and a cough for several days. He is cyanotic and has bilateral rales greater on the right than on the left, with intercostal retractions. His weight is 35 kg. Vital signs are pulse rate 160, respiratory rate 52, temperature 39.7°C (103.5°F), and oxygen saturation 81% on room air.

Because the child is cyanotic and in respiratory distress, a decision is made to intubate the child. During the intubation, the nurse asks if she should apply cricoid pressure. The physician responds that he will opt to do the intubation without using cricoid pressure since the Sellick maneuver is no longer mandatory, and he will use a cuffed endotracheal tube. Successful intubation is verified by capnography. The physician asks the respiratory therapist to titrate the oxygen, keeping the patient’s oxyhemoglobin saturation between 94% and 99% in order to avoid hyperoxemia.

While awaiting admission to the pediatric ICU, the boy becomes tachycardic with a heart rate of 200. An ECG shows supraventricular tachycardia (SVT). He is maintaining his blood pressure and oxygen saturation. A vagal maneuver is done, but the heart rate is unchanged, so adenosine at 0.1 mg/kg × 35 kg (0.35 mg) is given intravenously. There is no change in the heart rate, so a second dose of adenosine at 0.2 mg/kg × 35 kg (0.7 mg) is given intravenously. There is no change in the heart rate; his blood pressure drops to 50 systolic, and his pulse is now thready, so synchronized cardioversion at 1 J/kg × 35 kg (35 J) is administered. The blood pressure is 45 systolic, and the heart rate still 200, so synchronized cardioversion at 2 J/kg × 35 kg (70 J) is administered. The heart rate decreases to 130, the repeat blood pressure is 100/60, and the ECG now shows sinus tachycardia (Figure 1).

■ Case Three

A 3-year-old boy is brought in by his family because he has been unusually lethargic; they think he may have taken an unknown medicine. His past medical history is negative. He has no allergies and is not taking any prescription medications. His weight is 25 kg. An intravenous line is placed, and the child is put on a monitor. He is lethargic but has spontaneous respirations with a normal oxygen saturation.

Vital signs are blood pressure 55/40, heart rate 30, respiratory rate 14, and oxygen saturation 94% on room air. The ECG shows complete heart block. Chest compressions are started, and epinephrine, 0.01 mg/kg IV (0.25 mg) is given. After 2 minutes, the child is still bradycardic with poor perfusion despite adequate oxygenation and ventilation, so atropine, 0.02 mg/kg IV (0.50 mg), is administered. At 3 minutes after the first dose of epinephrine, a second dose of epinephrine, 0.01 mg/kg IV (0.5 mg), is administered. Repeat vital signs are blood pressure 90/60, heart rate 85, respiratory rate 20, and oxygen saturation 96% on room air. He is admitted to the pediatric ICU (Figure 2).

CRITICAL DECISION

What is the sequence of steps in CPR recommended in the 2010 guidelines?

The major change in the sequence of steps for cardiopulmonary resuscitation (CPR) is from airway, breathing, chest compressions (A-B-C) to chest compressions, airway, breathing (C-A-B). This is based on the fact that although ventilations are important during resuscitation, the key parameter in adult resuscitation (and by extrapolation, pediatric resuscitation, as well) is chest compressions. The downside of the A-B-C sequence is that compressions are often delayed while the airway is opened and...
breaths are delivered. In the new guidelines, anything that delays chest compressions is to be avoided (Table 1).

According to the old and new sequence for cardiopulmonary resuscitation, the first step remains a check for responsiveness, followed by step 2, a call for help and for an AED. However, the check for breathing is now incorporated into step 1, where the patient is checked not only for responsiveness but also for breathing.4

Previously, the check for breathing was separate from the check for responsiveness and occurred after the airway was opened and before chest compressions or A-B-C. The

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“look, listen, and feel for breathing” has been removed from the sequence for assessment of breathing after opening the airway. Now, breathing should be briefly checked for by health care providers when checking for responsiveness. The check for breathing is incorporated into the check for cardiac arrest. Again, taking some extra time to specifically “look, listen, and feel” takes time away from chest compressions.

Although most pediatric cardiac arrests are not from a sudden primary cardiac arrest but are asphyxial and from respiratory failure and/or shock, the literature still supports the necessity of both ventilations.

**Figure 2.**
and chest compressions for pediatric CPR. It is also true that many rescuers fail to begin CPR because they are confused or unsure about CPR and that pediatric cardiac arrest victims fail to receive any bystander CPR, any process that increases the probability of bystander CPR is likely to save lives. With this background, adoption of the C-A-B sequence for all ages is hoped to increase the initiation of bystander CPR and save lives. Moreover, since it takes less than 18 seconds to deliver 30 compressions with two-rescuer CPR, the maximum theoretical delay in rescue breaths would only be 18 seconds.

**CRITICAL DECISION**

**What are the 2010 AHA recommendations for chest compressions in pediatric patients (eg, depth, rate, and time to initiate compressions)?**

The emphasis in the 2010 guidelines is on high-quality CPR with high-quality chest compressions. The new mantra is “push hard, push fast” and push as soon as possible. With the focus on effective chest compressions, there are multiple changes in how chest compressions should be done. First, begin chest compressions as soon as possible. Chest compressions should be started within 10 seconds of recognition of the arrest. Next, push hard, and push fast. The new compression depths are greater than those previously recommended. The new recommendations for depth of chest compressions for children are at least one-third the anterior-posterior chest diameter or about 2 inches (5 cm); previous recommendations were one-third to one-half the diameter of the chest. For infants, the new recommendation is at least one-third the chest diameter or about 1½ inches (4 cm); the previous guidelines were one-third to one-half the diameter of the chest.

The literature indicates that pushing hard is needed in order to achieve effective chest compressions and that the suggested depth of chest compressions is approximately 2 inches (5 cm) in most children and 1½ inches (4 cm) in most infants. These deeper compressions are necessary in order to generate the pressures required to perfuse the cerebral and coronary arteries.

The “push fast” mandate is to ensure that each set of chest compressions should take 18 seconds or less versus the previous recommendation for completion of chest compressions within 23 seconds or less (Table 2). Faster compressions are needed to deliver the pressures required in order to perfuse the cerebral and coronary arteries.

**CRITICAL DECISION**

**What are the new recommendations for AED use in infants and children?**

In the new guidelines, an AED may be used in infants (<1 year of age). A manual defibrillator is preferred for use in infants. However, if a manual defibrillator is not available, then an AED with a pediatric dose attenuator is the second choice, and if this is not available, then an AED without a dose attenuator may be used, but this is the third choice. In the previous guidelines, there was insufficient data to recommend for or against the use of an AED in infants so this is a new recommendation for infants (<1 year of age). The 2010 recommendation for AED use in children is the same as the 2005 recommendation. For children (ages 1 to 8 years), an AED with a pediatric dose attenuator should be used if available. However, if one with a pediatric dose attenuator is not available, then a standard AED may be used.

No documented adverse effects have been reported when AEDs with...

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### Table 1

Comparison of the sequence of steps in cardiopulmonary resuscitation between the 2010 and the 2005 guidelines

<table>
<thead>
<tr>
<th>Step</th>
<th>2010 Guidelines</th>
<th>2005 Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR sequence</td>
<td>C-A-B (chest compressions-airway-breathing)</td>
<td>A-B-C (airway-breathing-chest compressions)</td>
</tr>
<tr>
<td>CPR step 1</td>
<td>Check responsiveness and breathing</td>
<td>Check responsiveness</td>
</tr>
<tr>
<td>CPR step 2</td>
<td>Call for help, get AED</td>
<td>Call for help, get AED</td>
</tr>
<tr>
<td>CPR step 3</td>
<td>Check pulse</td>
<td>Open airway, “look, listen, feel”</td>
</tr>
<tr>
<td>CPR step 4</td>
<td>Give compressions</td>
<td>Give 2 breaths, check pulse</td>
</tr>
<tr>
<td>CPR step 5</td>
<td>Open airway, give 2 rescue breaths</td>
<td>Give compressions</td>
</tr>
<tr>
<td>CPR step 6</td>
<td>Resume compressions</td>
<td></td>
</tr>
<tr>
<td>Check for breathing</td>
<td>Incorporated into step 1, check for responsiveness and breathing</td>
<td>After airway is opened, check for breathing</td>
</tr>
<tr>
<td>“Look, listen, feel”</td>
<td>Omit “look, listen, feel”</td>
<td>“Look, listen, feel” after opening the airway</td>
</tr>
<tr>
<td>Rescue breaths</td>
<td>Each breath takes 1 second</td>
<td>Each breath takes 1 second</td>
</tr>
<tr>
<td>Rescue breaths (after advanced airway placed)</td>
<td>1 breath every 6-8 seconds (8-10 breaths/min)</td>
<td></td>
</tr>
</tbody>
</table>
fairly high energy doses were used to successfully resuscitate infants in cardiac arrest.

**CRITICAL DECISION**
What are the current recommendations with regard to airway and breathing?

As mentioned previously, airway now takes a back seat to chest compressions, which are first and foremost.\textsuperscript{4,5} Chest compressions occur before airway and breathing in the steps of CPR (C-A-B). \textsuperscript{4}“Look, listen, and feel” as a distinct or separate check for breathing has been eliminated with incorporation of breathing into the check for responsiveness as part of the new guidelines (Table 1).

Cricoid pressure, the Sellick maneuver, is no longer routine or mandatory but, instead, is an option. Aspiration can occur even when cricoid pressure is used. It is difficult to teach rescuers how to perform the Sellick maneuver, and it is often applied incorrectly even by trained health care providers. Furthermore, in some cases, cricoid pressure can impede passage of an endotracheal tube.\textsuperscript{6}

Cuffed endotracheal tubes may be used in infants and children.

The use of capnography/capnometry is suggested for confirmation of endotracheal tube position and can be used during CPR to evaluate and improve the quality of chest compressions.\textsuperscript{4}

**CRITICAL DECISION**
What dosages are acceptable for the defibrillation of infants and children, and what is the shock sequence?

The new recommendations allow the use of higher doses for defibrillation of infants and children for both the initial and subsequent defibrillation.\textsuperscript{7} Under the 2010 recommendations it is acceptable to use 2 to 4 J/kg for the initial energy dose, whereas the 2005 guidelines called for 2 J/kg for the first attempt and 4 J/kg for subsequent attempts. Currently, providers may consider subsequent energy levels of at least 4 J/kg and higher energy levels, up to but not exceeding 10 J/kg or the adult maximum dose (Table 3).

In the 2005 guidelines three shocks were to be given in rapid sequence. The new guidelines recommend that a single shock be followed by 2 minutes of high-quality chest compressions.

Although the optimal defibrillation dose for pediatric patients is unknown, there have been case reports and animal studies suggesting that higher doses can be successful without any adverse effects.

**CRITICAL DECISION**
How have the pharmacology recommendations changed in the 2010 guidelines?

Atropine is no longer recommended for routine use in the management of pulseless electrical activity (PEA)/asystole and has been deleted from the ACLS cardiac arrest algorithm. In the 2005 guidelines, atropine was included in the ACLS pulseless arrest algorithm and could be considered for asystole or slow PEA. The literature indicates that routine use of atropine during PEA or asystole is unlikely to have a therapeutic benefit.

Adenosine is now suggested for the initial treatment of stable, undifferentiated, regular, monomorphic, wide complex tachycardia, although it should not be used if the pattern is irregular. Previously, in the tachycardia algorithm, adenosine was

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**Table 2.**
Comparison of chest compression recommendations between the 2010 and the 2005 AHA guidelines

<table>
<thead>
<tr>
<th></th>
<th>2010 Guidelines</th>
<th>2005 Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initiation of compressions</strong></td>
<td>Compressions begun before ventilations</td>
<td>Compressions begun after assessment of airway/breathing and after ventilations given</td>
</tr>
<tr>
<td></td>
<td>Begin compressions within 10 seconds of recognition of arrest</td>
<td></td>
</tr>
<tr>
<td><strong>Compression rate</strong></td>
<td>At least 100/min (&gt;100/min)</td>
<td>About 100/min (=100/min)</td>
</tr>
<tr>
<td><strong>Time to complete cycle of 30 compressions</strong></td>
<td>≤18 seconds</td>
<td>≤23 seconds</td>
</tr>
<tr>
<td><strong>Compression depth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infants</td>
<td>At least (&gt;1) one-third diameter of chest = 1.5 inches = 4 mm</td>
<td>One-third to one-half chest diameter</td>
</tr>
<tr>
<td>Children</td>
<td>At least (&gt;1) one-third diameter of chest = 2 inches = 5 mm</td>
<td>One-third to one-half chest diameter</td>
</tr>
<tr>
<td>Adults</td>
<td>At least (&gt;1) 2 inches = 5 mm</td>
<td>1.5-2 inches</td>
</tr>
<tr>
<td><strong>Compression-to-ventilation ratio</strong></td>
<td>30:2 single rescuer of adults, children, infants (excludes newly born)</td>
<td>Same (no change)</td>
</tr>
<tr>
<td><strong>Chest recoil</strong></td>
<td>Allow complete chest recoil after each compression</td>
<td>Minimize interruptions in chest compressions</td>
</tr>
<tr>
<td></td>
<td>Minimize interruptions in chest compressions</td>
<td>Avoid excess ventilation</td>
</tr>
</tbody>
</table>
recommended only for suspected regular narrow complex reentry supraventricular tachycardia. The data suggest that adenosine is safe and may be effective in the treatment of undifferentiated regular monomorphic, wide-complex tachycardia when the rhythm is regular.

In adults with symptomatic and unstable bradycardia, chronotropic drug infusions can now be used as an alternative to pacing, while in the previous bradycardia algorithm, chronotropic drug infusions were to be used after atropine while awaiting a pacer or if pacing was ineffective. Regarding the routine use of calcium, the previous guidelines commented that calcium does not improve the outcome of cardiac arrest. The new guidelines are more emphatic and state that “it (calcium) is not recommended,” except in specific circumstances, such as documented hypocalcemia, hyperkalemia, hypermagnesemia, and calcium channel blocker overdose.6,7

The new guidelines suggest limiting the use of etomidate in pediatric patients with septic shock. This is because of concern over adrenal suppression that has been reported even with one dose of etomidate8 (Table 4).

**CRITICAL DECISION**

**What are the key recommendations for pediatric post-arrest or postresuscitation care?**

Continuous waveform capnography is recommended to confirm endotracheal tube position in all settings throughout the peri-arrest period and in adults can also be used to monitor CPR quality and detect return of spontaneous circulation based on end-tidal carbon dioxide values. Previously, an exhaled carbon dioxide detector or an esophageal

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**Pearls**

- The critical element in resuscitation is chest compressions not ventilations, so compressions are done before ventilations.
- The recommended CPR sequence is now chest compressions, airway, breathing.
- Higher energy doses (>4 J/kg and as high as 9 J/kg) have provided effective defibrillation in children and animal models of pediatric arrest with no significant adverse effects.
- The new definition of wide complex tachycardia is a QRS width greater than 0.09 seconds (previous definition was 0.08 seconds).
- Post-arrest, avoid hyperoxia by titrating oxygen administration to maintain arterial oxyhemoglobin saturation between 94% and 100%.
- Postresuscitation, therapeutic hypothermia may be useful in adolescents.

**Pitfalls**

- Failing to recognize that the A-B-C sequence delays compressions; the C-A-B sequence is the new recommendation.
- Using too low a dose for pediatric defibrillation (initial 2-4 J/kg, subsequent at least 4 J/kg, up to 10 J/kg or adult maximum dose).
- Assuming that cricoid pressure will prevent aspiration.
- Failing to recognize that cricoid pressure may impede passage of an endotracheal tube in some patients.
- Administering calcium routinely for cardiopulmonary arrest.

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### Table 3.
Comparison of electrical therapy recommendations between the 2010 and the 2005 AHA guidelines

<table>
<thead>
<tr>
<th></th>
<th>2010 Guidelines</th>
<th>2005 Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>AED use in infants</td>
<td>May use manual defibrillator; if this is not available, may use AED with pediatric dose attenuator; if this is not available then may use AED without a dose attenuator</td>
<td>Insufficient data to recommend for or against AED in infants</td>
</tr>
<tr>
<td><strong>Defibrillation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defibrillation dose</td>
<td>2-4 J/kg for initial attempt, consider ≥4 J/kg for subsequent up to maximum of 10 J/kg or adult dose</td>
<td>2 J/kg for initial attempt, 4 J/kg for subsequent attempts 3-shock sequence for VF</td>
</tr>
<tr>
<td>Defibrillation sequence</td>
<td>There is no “sequence” of shocks. A single shock is followed by 2 minutes of high-quality chest compressions</td>
<td>3 shocks are administered in rapid sequence</td>
</tr>
</tbody>
</table>
detector device was recommended to confirm endotracheal tube placement. Continuous waveform capnography is the most reliable method of confirming and monitoring correct endotracheal tube placement.

For postresuscitation care, there is a new recommendation: once spontaneous circulation has been restored, the inspired oxygen should be titrated to maintain an arterial oxyhemoglobin saturation between 94% and 100% in order to minimize the risks of hyperoxemia. There were no specific recommendations for the titration of inspired oxygen in the previous guidelines, although the risk for reperfusion injury was mentioned. The literature suggests that hyperoxemia (i.e., a high Pa\textsubscript{O\textsubscript{2}}) increases the oxidative injury seen after ischemia-reperfusion that can occur after resuscitation from cardiac arrest.

For adolescents who remain comatose after resuscitation from sudden witnessed out-of-hospital ventricular fibrillation cardiac arrest, therapeutic hypothermia (32°C to 34°C) can be beneficial and may be considered for infants and children who remain comatose after resuscitation from cardiac arrest. Although extensive pediatric data are lacking, adult studies document a benefit from therapeutic hypothermia for comatose patients after cardiac arrest.

**The Science Behind the Recommendations**

**The International Liaison Committee on Resuscitation (ILCOR) Evidence-Based Medicine Process**

What is the evidence-based medicine behind the new guidelines or what is the resuscitation science underlying the new guidelines? As mentioned previously, there is an extensive process, over several years, which culminated in the production of worksheets, an international conference, and eventually the new recommendations. These worksheets can be accessed online (http://circ.ahajournals.org/content/122/16_suppl_2/S606.full.pdf+html), and the recommendations are published simultaneously in the journals

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**Case Resolution**

**Case One**

On arrival in the emergency department, paramedics are continuing CPR with chest compressions on the 2-month-old girl who was found unresponsive in her crib. After 2 minutes of CPR, the infant has return of spontaneous circulation. An endotracheal

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**Table 4.**

Comparison of the pharmacology recommendations between the 2010 and the 2005 AHA guidelines

<table>
<thead>
<tr>
<th></th>
<th>2010 Guidelines</th>
<th>2005 Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Not recommended except for hypocalcemia, hyperkalemia, hypermagnesemia, calcium channel blocker overdose</td>
<td>Does not improve outcome of cardiac arrest</td>
</tr>
<tr>
<td>Etomidate</td>
<td>Consider limiting etomidate use in pediatric patients with septic shock</td>
<td>No recommendation</td>
</tr>
<tr>
<td>Atropine</td>
<td>Not recommended for routine use in PEA/asystole (is used in bradycardia algorithm)</td>
<td>Can be used in PEA/asystole</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Not recommended for routine use for VF/pulseless VT</td>
<td>Can be used for VF/pulseless VT</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Not recommended for routine use for VF/pulseless VT</td>
<td>Can be used for VF/pulseless VT</td>
</tr>
<tr>
<td>Chronotropic drug infusion</td>
<td>Can be used as alternative to pacing (instead of after pacing) in symptomatic unstable bradycardia</td>
<td>Can be used after atropine and if transcutaneous pacing fails</td>
</tr>
<tr>
<td>Adenosine</td>
<td>Can be used for narrow complex SVT, and for undifferentiated regular monomorphic wide complex tachycardia</td>
<td>Can be used for narrow complex tachycardia (SVT)</td>
</tr>
<tr>
<td>Amiodarone or procainamide</td>
<td>Do not routinely use both drugs simultaneously, seek consult when using in stable patients</td>
<td>Can be used for narrow complex tachycardia (SVT)</td>
</tr>
</tbody>
</table>
tube (cuffed) is inserted, and continuous waveform capnography is applied confirming the successful endotracheal intubation. She is admitted to the pediatric ICU where postresuscitation care guidelines are followed. Her oxygen is titrated to maintain an arterial oxyhemoglobin saturation between 94% and 100% to minimize the risks of hyperoxemia. The pediatric intensivists consider therapeutic hypothermia; however, retinal hemorrhages are seen on ophthalmoscopic examination, and a computed tomography scan of the brain indicates multiple severe intracerebral hemorrhages. A diagnosis of shaken-baby syndrome is made, and the infant dies the next day.

■ Case Two
The 6-year-old boy who presented with difficulty breathing and became tachycardic is given antibiotics and admitted to the pediatric ICU with a diagnosis of pneumonia. He is discharged home 4 days later on oral antibiotics.

■ Case Three
In the case of the 3-year-old with the suspected drug ingestion, the family brings in an empty bottle of the grandmother’s heart medicine. It is discovered that the child took an overdose of a β-blocker. As the effects of the overdose wear off, the child becomes more responsive, and both his heart rate and blood pressure return to the normal range. He does well and is discharged home 2 days later.

Summary
Although there are many changes in the “2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care,” the new guidelines focus on the importance of high-quality CPR with high quality chest compressions (“push hard, push fast”) and a new C-A-B compressions-airway-breathing sequence.

References

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