

Procedure 17: Cardiopulmonary Resuscitation

Introduction

Cardiopulmonary arrest (CPA) occurs when a patient's heart and lungs stop functioning. In children, CPA usually begins as a primary respiratory arrest. This is in contrast to adults, in whom CPA or "sudden death" is almost always a primary cardiac event that occurs with onset of ventricular fibrillation and an abrupt change in the heart's electrical activity. Because cessation of effective breathing is the precipitating factor in pediatric CPA, airway management and ventilation are to children in CPA what defibrillation is to adults. Cardiopulmonary resuscitation (CPR) refers to basic airway management, artificial ventilation, and chest compressions to provide oxygen and circulation to core organs: the heart, brain, and lungs. In children, CPR has been shown to improve survival from drowning, and it may also benefit patients in CPA from other causes.

Indications

Newly born, neonate, infant, or child of any age who is apneic and pulseless
 Newly born with a heart rate less than 60 beats/min and not improving after standard newborn care
 Neonate, infants and children with a heart rate less than 60 beats/min and poor perfusion.

Contraindication

Newly born, infant, or child with effective perfusion (palpable central or peripheral pulse)

Equipment

Mouth-to-mask device
 Bag-mask device, infant or child
 Airway adjuncts
 Appropriate mask sizes

Rationale

CPR encompasses the basic procedures for sustaining critical oxygenation, ventilation, and perfusion recommended by the American Heart Association. The pediatric techniques are slightly modified from the adult techniques to reflect the known differences in CPA between age groups. Furthermore, there are specific differences between infants and children, including num-

ber of rescuers, placement of hands and fingers, rates of ventilation, and rates and depth of chest compressions.

Preparation

1. Position a child on a hard surface. Position a neonate or infant on a hard surface or on the forearm of the rescuer with the hand supporting the head.

Procedure

17-1 Assess Responsiveness

- 1 Assess responsiveness.



- 2 If unresponsive, assess breathing.



Procedure**17-2 Assess Breathing**

1 Open airway using either the head-tilt/chin-lift maneuver (medical patient) or modified jaw thrust maneuver (trauma patient) to achieve a neutral position.



2 If spinal injury is possible, have a second rescuer maintain manual spinal stabilization.



3 Look, listen, and feel for signs of breathing.

4 Remove any obvious obstructions, such as loose teeth or vomitus.

**Tip**

Manipulation of the head to keep the airway in a neutral position is essential for effective ventilation. A towel roll under the shoulders of the infant or small child may help maintain neutral head position.

Compression Rates

These are the timing rates for single rescuers, not the actual number of compressions delivered each minute because of pauses for ventilations and reassessments.

- Newly born: At least 120 events/min
- Neonate and infant: 100 compressions/min
- Child 1–8 years: 100 compressions/min
- Child over 8 years: 100 compressions/min

Possible Complications

Coronary vessel injury
 Diaphragm injury
 Hemopericardium
 Hemothorax
 Interference with ventilation
 Liver injury
 Myocardial injury
 Pneumothorax
 Rib fractures
 Spleen injury
 Sternal fracture

Procedure**17-3 Ventilation Rate**

1 If not breathing, begin mouth-to-mask ventilation, or perform bag-mask ventilation with 100% oxygen. Give two initial breaths at a rate of 1 second per breath.



2 If first breath does not expand the chest, reposition the head and attempt again. If breaths are still ineffective, suction the mouth with a bulb syringe or flexible suction catheter (newly born) or a large-bore rigid suction catheter (neonates, infants, and children) and attempt breaths again.



3 If breaths now expand the chest, assess pulse. Take no more than 10 seconds.



4 If pulse is present (≥ 60 beats/min), but the victim is still not breathing, continue ventilations. Give one every 2 seconds in newly born and rescue breaths at a rate of 12 to 20 breaths per minute (every 3 to 5 seconds) until spontaneous breathing resumes.



5 Slowly repeat "squeeze-release-release" to time bag-mask ventilation rate.



6 Use the E-C clamp technique to achieve a good mask seal and watch for adequate chest rise to ensure effective ventilation.



Continuously assess effectiveness of CPR by ensuring chest rise and feeling for a palpable pulse every 2 minutes.

Procedure

17-4 Compression Rate

1 Check central pulse. Newly born: umbilical cord stump or listen to **precordium**. Neonate and infant: brachial pulse or femoral pulse. Child: carotid pulse.

2 If pulse is absent or if heart rate is less than 60 beats/min, with shock or poor peripheral perfusion, begin chest compressions. Newly born: 3 compressions: 1 ventilation. Neonate, infant, and child: one rescuer 30 compressions: 2 ventilations, two rescuers 15 compressions: 2 ventilations. Use proper compression technique, compression-ventilation ratio, depth of compression, and compression-release ratio (Tables P17-1 and P17-2).

Table P17-1

Compression and Ventilation Rates per Minute*

Age	Rate of Compressions (min)	Rescue Breaths per Minute without Compressions (mouth to mouth or mask)	Rescue Breaths per Minute with Compressions with Advanced Airway
Newly born (<1 day)	120	30	30
Neonate (1–28 days) and infant (1–12 months)	100	12–20	8–10
Child 1–8 years	100	12–20	8–10
Child over 8 years One or two rescuers	100	10–12	8–10

*The rate of compressions and the actual number of compressions delivered per minute are different. The rate of compressions refers to the timing of compressions when they are being performed, and the rate does not account for pauses for breathing. Delivered compressions are the actual number of compressions delivered per minute after accounting for breathing. The ratios are calculated from the timing rates, not the delivered rates.

Table P17-2

Parameters for BLS Resuscitation for Health Care Providers

Age	Compressions (min)	Compression to Ventilation Ratio	Depth (in)	Hand Placement for Compression
Newly born (<1 day)	120	3:1	$\frac{1}{3}$ depth of chest	2 fingers at lower $\frac{1}{3}$ of sternum, 1 finger below nipple line, or 2 thumbs at midsternum with hands encircling chest
Neonate (1–28 days) One rescuer	100	30:2	$\frac{1}{3}$ to $\frac{1}{2}$ depth of chest	2 or 3 fingers at lower $\frac{1}{3}$ of sternum, 1 finger below nipple line
		Two rescuers		15:2
Infant (1–12 months) One rescuer	100	30:2	$\frac{1}{3}$ to $\frac{1}{2}$ depth of chest	2 fingers at midsternum, 1 finger below nipple line
		Two rescuers		15:2
Child 1–8 years One rescuer	100	30:2	$\frac{1}{3}$ to $\frac{1}{2}$ depth of chest	Heel of 1 or 2 hands at lower $\frac{1}{2}$ of sternum (do not push on xiphoid process)
		Two rescuers		
Child over 8 years One or two rescuers	100	30:2	1.5–2.0 inches	Heel of one hand, other hand on top, at lower $\frac{1}{2}$ of sternum between nipples

Procedure

17-5 Finger or Hand Placement

1 Newly born: Use the two thumb encircling chest method for the newborn. The two finger method is acceptable, but should be used when the two thumb method is not easily accomplished. Compression depth should be one third of chest depth. Two thumb technique: encircle the chest and use thumbs just below the **intermammary** line with the fingers supporting the spine. Two finger technique: Use two fingers on the lower $\frac{1}{3}$ of the **sternum** just below the intermammary line, with the other hand supporting the spine.

2 Lay rescuers and lone health care providers use two finger technique. Two health care providers use two thumbs encircling hands technique.



3 Child (1 to 8 years old): Use the heel of one hand on the sternum above the xiphoid process. Compression depth should be one third to one half the depth of the chest.



4 Child (> 8 years): Use the heel of both hands on the sternum above the xiphoid process.



Procedure

17-6 Compressions

1 The depth of chest compressions should be approximately one third to one half the depth of the chest. Compressions should be deep enough to produce a palpable brachial, femoral, or carotid pulse. Push hard and fast and release completely to allow chest to fully rise.

2 Use the two-rescuer technique when possible.

3 Reassessment: Check pulse after approximately every 5 compression-ventilation cycles.



A common problem in the transition from one-rescuer to two-rescuer child CPR is the lack of coordination between ventilations and compressions.

Procedure 18: AED and Defibrillation

Introduction

Synchronized cardioversion for tachydysrhythmias has long been part of adult emergency care and is one of the most effective treatments for sudden cardiac arrest from ventricular dysrhythmias. However, ventricular dysrhythmias are rare in children, especially in infants, and pediatric supraventricular tachycardia (SVT) is usually treatable with medical therapy. For these reasons, pediatric synchronized cardioversion is not often indicated. However, when a child develops ventricular fibrillation or pulseless ventricular tachycardia, defibrillation (unsynchronized cardioversion) may be life-saving. Also, synchronized cardioversion may resuscitate a child in shock with SVT. Use the

synchronized mode when there is SVT or ventricular tachycardia with a pulse, and the **asynchronized** (defibrillation) mode for ventricular fibrillation or ventricular tachycardia without a pulse.

Indications

Ventricular fibrillation
 Pulseless ventricular tachycardia
 SVT with shock and no vascular access rapidly available (synchronized)
 Ventricular tachycardia with shock and unresponsiveness with pulse and no vascular access rapidly available
 Atrial fibrillation or atrial flutter with shock

Contraindication

Conscious patient with good perfusion

Equipment

Automatic external defibrillator
 Standard defibrillator
 Newer models feature lower power outputs to deliver lower energy countershocks

Rationale

When a child's heart deteriorates into ventricular tachycardia or fibrillation, there is usually a severe systemic insult such as profound hypoxia, ischemia, electrocution, or myocarditis. Death may result if treatment is delayed. SVT, in contrast, is usually a more stable cardiac rhythm. When the child is pulseless and has ventricular fibrillation or ventricular tachycardia, perform defibrillation as quickly as possible with the appropriate technique. If a child has SVT or ventricular tachycardia and shock, use synchronized cardioversion. Do not attempt to perform synchronized cardioversion on a child with SVT who is well perfused.

Preparation

1. Open airway and ventilate with bag-mask device with 100% oxygen while assembling equipment for cardioversion or defibrillation.
2. If child is pulseless, begin closed-chest compressions, until automatic external defibrillator (AED) or conventional defibrillator is available.



Do not deliver synchronized cardioversion to a conscious child with SVT or ventricular tachycardia unless the child is in shock and has no IV or IO access rapidly available for medical treatment.



For a child with ventricular fibrillation or pulseless ventricular tachycardia, use the asynchronized (defibrillation) mode.

Procedure

18-1 Conventional Defibrillator Use

1 Apply the paddles directly to the skin. Place one paddle on the anterior chest wall on the right side of the sternum inferior to the clavicle and the other paddle on the left midclavicular line at the level of the **xiphoid process**. As another option, use the anterior-posterior position.



2 Clear the nearby area to avoid shocking someone. Announce, "I am going to shock on three. One, I am clear. Two, you are clear. Three, everybody is clear."



3 Begin recording rhythm. Deliver the electrical countershock with firm pressure.



4 Assess the patient for evidence of **reperfusion** and check the monitor for the rhythm.



5 If the first electrical shock is unsuccessful, deliver additional electrical countershocks as per EMS protocol. Give specific dysrhythmia treatment with epinephrine or other drugs, as

per EMS protocol. Treat bradycardia or other dysrhythmias.



2
Controversy

The preferred paddle location in children is controversial and no study in humans has compared the two techniques. Anterior chest wall placement has the advantage of a supine child and easier airway management. Anterior-posterior placement may allow larger paddles and more effective delivery of the charge.

Preparation

Conventional Defibrillator Use

- 1.** Select the proper paddle size. Use the 8-cm adult paddles if these will fit on the chest wall; otherwise, use the 4.5-cm pediatric paddles (Table P18-1).
- 2.** Prep paddles or skin electrodes with electrode jelly, paste, or saline-soaked gauze pads, or use self-adhesive defibrillator pads. Do not let jelly or paste from one site touch the other and form an "electrical bridge" between sites, which could result in ineffective defibrillation or skin burns.
- 3.** Establish appropriate electrical charge (Table P18-2).
- 4.** Select synchronized or asynchronized mode.
- 5.** Properly charge pack and stop chest compressions.

Table P18-1	Paddle Size
8-cm adult paddles (Use in children over 12 months of age or weighing more than 10 kg) On anterior chest wall, OR Anterior-posterior	
4.5-cm pediatric paddles (Use in infants up to 12 months of age or weighing less than 10 kg) on the anterior chest wall	

Blip

Failure to firmly apply paddles to the chest wall will decrease effective delivery of charge.

Procedure

18-2 One Rescuer with an AED

For children under 8 years of age use a child-pad cable system if available. There are inadequate data to recommend AED use for the child less than 1 year of age.

- 1 Verify unresponsiveness.



- 2 Open the airway, and check for breathing.



- 3 If the victim is not breathing effectively, give two ventilations.



- 4 Check for signs of circulation. If there are no signs of circulation, attach the AED and proceed with the AED treatment algorithm. The AED operator should take the following actions.



- 5 **POWER ON** the AED and follow voice prompts. Some devices will turn on when the AED lid or carrying case is opened.



- 6 **ATTACH** the AED. Select the correct pads for victim's size and age (adult vs. child). Peel the backing from the pads. Attach the adhesive pads to the victim as shown on the pads. (If only adult pads are available, and they overlap when placed on the chest, use an anterior [chest] and posterior [back] placement.) Attach the electrode cable to the AED (if not preconnected).



- 7 Allow the AED to **ANALYZE** the victim's rhythm ("clear" victim during analysis). **Deliver a SHOCK if needed** ("clear" victim before shock).



Reasonable variations in this sequence are acceptable.

Table P18-2

Appropriate Electrical Charge for Countershock

Dysrhythmia	Mode	Charge
Ventricular fibrillation	Defibrillation (asynchronized)	2 J/kg, then 4 J/kg, then 4 J/kg, as needed.
Ventricular tachycardia without a pulse		Then 4 J/kg after CPR and each dose of medication.
Ventricular tachycardia with pulse	Synchronized	0.5–1.0 J/kg. Repeat as needed.
SVT		
Atrial fibrillation and atrial flutter with shock		

Possible Complications

- Ineffective delivery of countershock because of failure to charge, improper positioning on the chest, incorrect paddle size, or improper conduction medium
- Burns on the chest wall
- Failure to "clear" before voltage discharge, leading to electrical shock of a team member or bystander
- Tachydysrhythmia
- Bradycardia
- Myocardial damage or necrosis
- Cardiogenic shock
- Embolic phenomena

Procedure

18-3 Two Rescuer AED Sequence of Action

Adapted from *Circulation* 2005; 112: IV 35–46.

- 1 Verify unresponsiveness.** If victim is unresponsive, have partner call 9-1-1. Get AED.



- 2 Open airway:** head-tilt/chin-lift (or jaw thrust if trauma is suspected).



- 3 Check for effective breathing:** provide breathing if needed. Check for breathing (look, listen, and feel). If not breathing, give two slow breaths. A mouth-to-mask device should be available in the AED carrying case.



- 4 Check for signs of circulation:** if no signs of circulation are present, perform these steps. Perform chest compressions and prepare to attach the AED. If there is any doubt that the signs of circulation are present, the first rescuer initiates chest compressions while the second rescuer prepares to use the AED. Remove clothing covering the victim's chest to provide chest compressions and apply the AED electrode pads.



- 5 Attempt defibrillation with the AED** if no signs of circulation are present. Place the AED near the rescuer who will be operating it. The AED is usually placed on the side of the victim opposite the rescuer who is performing CPR. The rescuer begins performing CPR while the rescuer who was performing CPR prepares to operate the AED. (It is acceptable to reverse these roles.)



- 6 The AED operator takes the following actions.** **POWER ON** the AED first (some devices will turn on automatically when the AED lid or carrying case is opened).



- 7 ATTACH** the AED to the victim. Select correct pads for the victim's size and age. Peel the backing from the pads. Ask the rescuer performing CPR to stop chest compressions. Attach the adhesive pads to the victim as shown on the pads. (If only adult pads are available, and they overlap when placed on the chest, use an anterior [chest] and posterior [back] placement.) Attach the AED connecting cables to the AED (if not preconnected). **ANALYZE** rhythm. Clear the victim before and during analysis. Check that no one is touching the victim. Press the ANALYZE button to start rhythm analysis (some brands of AEDs do not require this step). **"Shock Indicated" message.** Resume CPR until AED is charged and ready to deliver shock. Clear the victim once more before pushing the SHOCK button ("I'm clear, you're clear, everybody's clear"). Check that no one is touching the victim. Press the SHOCK button (victim may display muscle contractions). **"No Shock Indicated" message.** Check for signs of circulation (including a pulse). If signs of circulation are present, check breathing. If breathing is inadequate, assist breathing. If breathing is adequate, place the victim in the recovery position, with the AED attached.



- 8** If no signs of circulation are present, resume CPR for 5 cycles, then recheck for signs of circulation. If there are still no signs of circulation, analyze rhythm, repeat the analyze rhythm step, then follow the "shock indicated" or "no shock indicated" steps as appropriate.

