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Update on Pediatric Advanced Life Support: 2010 Guidelines

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Abstract

Management of cardiopulmonary arrest in children is one of the most important aspects of post graduate training in Pediatrics that needs understanding of current guidelines and expertise on skills of performing CPR. Team leader and every team member should know his/her role and limitations. New guidelines of performing CPR advocate compression-airway-breathing (C-A-B) rather than airway-breathing-compression (A-B-C) sequence practiced before. Here we discuss current CPR guidelines and use of common drugs during or immediately after performing CPR.

Keywords: Pediatric advanced life support; PALS; Cardiac arrest; Cardiopulmonary resuscitation; CPR.

Introduction

Cardiopulmonary arrests in children occur infrequently compared to adults (1). Of children who require resuscitation the majority are young (45 to 70 percent are less than one year old and 21 to 30 percent are one to four years of age) (2). Children who suffer *cardiopulmonary* arrests have poor outcomes with only 5 to 21 percent surviving to hospital discharge (3). Outcome of in hospital cardiac arrests is better than out of the hospital cardiac arrest victims. Children who have just respiratory arrests or shock have a much higher survival rate.

Pathophysiology

Cardiopulmonary arrests in children are caused by a wide range of problems. The most common causes include intravas-cular volume depletion due to traumatic hemorrhage, or illnesses such as gastroen-teritis, infectious diseases such as meningitis, sepsis, pneumonia, epiglottitis, croup, bronchiolitis and sudden infant death syndrome. Unlike adults, cardiac arrest in children is asphyxial arrest rather than sudden cardiac arrest due to congenital heart disease, myocarditis, or dysrhythmias (4). Though pediatric arrests are due to a wide range of etiologies, the final common pathway is usually respiratory failure and/or circulatory collapse, resulting in end -organ anoxia. Cardiac arrest probably occurs within five minutes of complete anoxia (5). Because cardiac arrest in children is predominately caused by anoxia, most children present with bradycardia or asystole. Only about 10 percent of children with cardiac arrest present with ventricular fibrillation and commonly have ventricular rhythms with cardiac arrest (1).

Clinical Presentation

Recognition of a cardiopulmonary arrest is not difficult. Clinical characteristics are cyanosis, a grayish hue, diaphoresis, mottling, unresponsiveness, agonal gasps and absence of respiration or pulses. Rapid recognition and institution of advanced life support is critical. Identifying the etiology of a cardiopulmonary arrest should follow the establishment of an airway, ventilation, and circulation. More difficult is the recognition of the pre arrest state- a child who is still awake but agitated and subtly tachypneic from hypoxia, and who has normal

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blood pressure but tachycardia with poor capillary refill. Given the poor outcome of children who suffer cardiopulmonary arrests, early intervention in these children can be lifesaving.

Pediatric Assessment

Inan arrest situation, the classical approach of taking a history, performing a complete examination, and performing initial laboratory tests before deciding on management is obviously not applicable. Instead these elements are interwoven.

Use "evaluate-identify-intervene" model to evaluate and treat a seriously ill or injured child. At any point you identify a life threatening problem, start life saving interventions immediately and get help by activating the emergency response system. *Initial impression* that is rapid visual and auditory assessment using pediatric assessment triangle (PAT) can be completed within the first few seconds of patient encounter. From the information gathered during assessment, *identify* the clinical condition of the child and *intervene* to implement appropriate treatment. Then reassess and repeat the process. Primary assessment includes rapid hands-on cardiopulmonary and neurological evaluation using ABCDE approach, assessment of vital signs and pulse oximetry if available. A child in cardiac arrest can be identified in first few seconds of encounter so life saving interventions must be started immediately. Further assessment via focused medical history, physical examination and ancillary lab studies to detect and identify the presence and severity of respiratory and circulatory abnormalities can be performed as dictated by the clinical situation (6).

Setting up a team

The presentation of a young child in cardiopulmonary arrest is anxiety- provoking and often results in a chaotic resuscitation. Optimal performance is derived from having a well-trained, experienced team with members having pre-assigned specific roles. The ideal size of team ranges between five and eight people. Too small a team makes it difficult to move rapidly through the resuscitation algorithm; too large a team causes unnecessary confusion. The team should include a leader as well as individuals assigned to manage the airway, perform chest compressions, establish venous access, place and maintain monitors, assess vital signs, draw up medications, and apply cardiac defibrillation. As soon as possible, an experienced team member should meet and talk with any family members available to ascertain recent and past medical history.

Assessment of Circulation/ Chest Compressions

If the child is found to be unresponsive, assess for 5-10 seconds for presence of carotid pulse (brachial in infants). If pulse is non-palpable, immediately initiate chest compressions before making any attempts to establish an airway.

The new AHA recommendation for the sequence of resuscitation is compression-airway-breathing (C-A-B) rather than airway-breathing-compression (A-B-C) as recommended before. Early chest compression is most critical step in the resuscitation to generate blood flow to vital organs and to achieve ROSC. It was found that attempts to secure the airway and deliver breath delays the initiation of chest compressions. Emphasis is now placed on immediate delivery of high quality CPR. Place heel of one hand in the centre of chest between nipples and other hand on top of the first hand to start effective compression. In infants compression should be delivered just below the nipple line by placing two fingers over the sternum. The two-thumb encircling technique can be adopted in the presence of 2 rescuers. Deliver chest compressions that depress the chest of the infant and child by one third of the anterior- posterior diameter of the chest which is usually 4 cm in infants and 5 cm in older children. Remember to *push hard, push fast* (rate of at least 100 compressions per minute), allow complete chest recoil between compressions, and minimize interruptions in compressions. Use a 30:2 compression-

ventilation ratio for all including adult CPR when there is only a single rescuer present and use a 15:2 compression ventilation ratio for infants and older children when 2 rescuers are present for the CPR (6).Once an advanced airway is in place (eg. endotracheal tube, Combitube, LMA) during 2-rescuer CPR, provide 100 compressions per minute without pausing for ventilation, and deliver 8 to 10 breaths per minute. See Table 1 for a summary of technique and rates based on age. Compressions should ideally be interrupted only for ventilation (until an advance airway is placed), rhythm check (after 2 minutes) and actual shock delivery. (7)

Table 1: Compression/ ventilation standards for pediatric resuscitation

Maneuver	**Adult** **Adolescent and older**	**Child** **1 year to adolescent**	**Infant** **< 1 year**
Pulse check	Carotid or femoral		Brachial or femoral
Compression landmarks	Centre of chest, between nipples		Just below nipple line
Compression method	2 hands	2 hands or 1 hand	1 rescuer: 2 fingers 2 rescuers: 2 thumbs encircling hands
Compression depth	1.5 to 2.0 inches	Approximately ? of anterior –posterior diameter of chest	
Compression rate	At least 100 per minute		
Compression-ventilation ratio	30:2 (1 or 2 rescuer)	30:2 (single rescuer) 15:2 (2 rescuer)	

**Child CPR guidelines for healthcare providers apply to victims from about 1 year of age to the onset of adolescence or puberty (about 12 to 14 years of age) as defined by the presence of secondary sex characteristics.*

Establishing an Airway and Assuring Ventilation

After 30 compressions open the airway using head tilt-chin lift maneuver and deliver 2 rescue breaths, each resulting in adequate chest rise and lasting one second each. The "Look, Listen and Feel" sequence of assessing breathing after opening airway has been removed from the current guidelines as the sequence of resuscitation of an unresponsive child is compressions first. If intubation cannot be accomplished immediately, patients can be ventilated temporarily with 100 percent oxygen by use of a bag and mask (most commonly a self-inflating bag with a reservoir). It is now recommended to safely use 100% oxygen during resuscitation; however the FiO2 needs to be decreased subsequently with a target saturation of 94-99%. If it is difficult to maintain an open airway, either place an appropriate size oropharyngeal airway or have a second person bag while the other maintains a patent, sealed oral airway.

Intubation should be accomplished as soon as feasible since it maximizes ventilation and minimizes the risk of aspiration (8). For infants and children cuffed tubes have been found to be as safe as un-cuffed ones in hospital settings as well as in emergency situations. Cuffed tubes may be preferable in certain circumstances such as poor lung compliance, high airway resistance or large glottic air leak (9). Keep cuff inflation pressure less than 20 cm H_2O (10). The size of ET tube can be estimated by matching the external diameter of the tube to the diameter of the child's little finger. See Table 2 for estimates of ET tube, laryngoscope blade, and suction catheter sizes based on age. The time required to intubate should be monitored, and prolonged efforts should be avoided by intermittent ventilation with 100 percent oxygen by mask. Routine application of cricoid pressure during

Table 2: Size of ET tubes, laryngoscopes, and catheters, based on age

	Internal Diameter of Endotracheal tube (mm)	Laryngoscope blade size	Suction Catheters (F)
Age	Uncuffed (age in years/4) + 4 Cuffed (age in years/4) + 3.5		2 X ET size
Newborn	2.5, 3.0 Uncuffed/cuffed	0-1	6F
6 months	3.5, 4.0 Uncuffed, 3 cuffed	1	8F
18 months	4.0 Uncuffed, 3.5 cuffed	2	8F
3 years	4.5 Uncuffed 4.0 Cuffed	2	8F
5 years	5.0, 5.5 Uncuffed 4.5 Cuffed	2	10 F
6 years	5.5 Uncuffed 5.0 Cuffed	2	10 F
8 years	6.0 Cuffed	2	12 F
12 years	6.5, 7.0 Cuffed	2	12 F
16 years	7.0, 8.0 Cuffed	3	12 F
Adult (F)	7.5-8.0 Cuffed	3	12F
Adult (M)	8.0-8.5 Cuffed	3	14 F

intubation has now fallen into disfavor. It can be discarded or modified if it interferes with the ease of intubation.

Appropriate placement of the ET tube should be promptly confirmed by physical examination i.e. adequate and symmetrical chest rise, equal breath sounds over proximal and peripheral lung fields and condensation in the tube with exhalation. Conformational devices include exhaled CO_2 detection by capnometry/ capnography, improvement in $SPO_{2,}$ esophageal detector device to demonstrate aspiration of air from trachea and chest-X-ray to confirm tube position. Capnometry/ calorimetry is now recommended to be used to confirm tracheal placement of the ET tube and also to monitor the quality of CPR. A persistently low ETCO2 (<15 mmHg) signals poor quality of chest compressions. It can also signal ROSC when it shows a sudden increase in exhaled CO2, thereby minimizing interruptions of chest compressions for pulse check. If there is any doubt about proper placement, the tube should be pulled and the patient is re-intubated (6).

Ventilation rates based on age are listed in Table 1. Ventilation volume should be 10 to 15 ml/kg; practically this volume can be approximated by bagging sufficient to lift the chest wall visibly (8). A naso- or orogastric tube should be placed after intubation to evacuate the stomach of air and of any other contents. Cricothyroidotomy or tracheostomy is *rarely* required.

Airway and ventilation should be repeatedly reassessed throughout resuscita-tion. In addition, the oxygen delivery system should be double-checked to assure that maximum oxygen is being delivered to the patient.

Establishing Venous Access

Vascular access is the next management priority in an acutely ill or injured child. Venous access should be obtained rapidly to allow the provision of fluids and drugs. Rapid venous access is more important than site of access. Immediate intraosseous access is recommended if no other intravenous access is already in place. If neither a bone marrow nor a specifically designed intraosseous needle is available, a two-

Table 3: Possible contributing factors in arrhythmias

6 H's	5 T's
Hypovolemia	**T**oxins
Hypoxia	**T**emponade, cardiac
Hydrogen ion (Acidosis)	**T**ension pneumothorax
Hypo-/hyper-kalemia	**T**hrombosis (coronary or pulmonary)
Hypoglycaemia	**T**rauma (hypovolemia)
Hypothermia	

inch, 18 or 20 gauge spinal needle can be used. The preferred location is on the flat, medial surface of the proximal tibial shaft 1 to 2 cm below the tibial tuberosity. Alternately, especially in older children or adolescents, a needle can be placed in the medial surface of the tibia proximal to the medial malleolus (11). All resuscitation drugs and fluids can be delivered rapidly and safely via this route. The IV and IO routes are preferred over the endotracheal route

During attempted resuscitation if an endotracheal tube is in place but vascular access is not yet available, lipid soluble resuscitation drugs namely lidocain, epinephrine, atropine and naloxone (LEAN) may be administered through ET tube although optimal endotracheal doses are unknown and drug level and effects are unpredictable (12). Flush with a minimum of 5 mL normal saline followed by 5 assisted manual ventilations (13).

Central venous access is obtained most reliably and rapidly by the Seldinger guide-wire technique via the femoral vein. The use of this route does not impinge on other aspects of resuscitation. Cannulation by the open or percutaneous cutdown technique *in unexperienced hands* is difficult and slow and generally should be avoided.

Assessment of Cardiac Rhythm

Management of any seriously ill or injured child requires assessment of heart rate and rhythm. Asystole and bradycardia with a wide QRS complex are most common in asphyxial cardiac arrest, VF and pulseless electrical activity (PEA) are less common and more likely to be observed in children with sudden arrest. Determine the rhythm, it may be slow (bradyarrhythmia), fast (tachyarrhythmia), or arrest (pulseless arrest). In pulseless arrest rhythm may be shockable (VF / VT without pulse) or nonshockable (asystole / pulseless electrical activity).

Pulseless arrest

Shockable rhythm (VF / VT)

VF occurs in 5% to 15% of all pediatric victims of out-of hospital cardiac arrest and up to 20% of pediatric in-hospital arrests. Defibrillation is the definitive treatment for shockable rhythms. When using a manual defibrillator use the largest paddles that will fit on the chest wall without touching each other. Use infant paddles for infants weighing <10 kg and adult paddles for children >10 kg. Apply electrode– chest wall interface like conductive gel, electrode cream, paste, or self-adhesive monitoring-defibrillation pads. Do not use saline-soaked pads, ultrasound gel, bare paddles, or alcohol pads. Apply firm pressure on the paddles (manual) placed over the right side of the upper chest and the apex of the heart (to the left of the nipple over the left lower ribs). Alternatively place one electrode on the front of the chest just to the left of the sternum and the other over the upper back below the scapula (14).

Taking all precautionsGive 1 shock (2-4 J/kg) as quickly as possible and immediatelyresume CPR, beginning with chest compressions. Continue CPR for 5 cycles(about 2 minutes) and again check the rhythm. If a shockable rhythm

persists, give subsequent shocks of 4 J/kg atleast or even higher doses upto a maximum of 10J/kg, and resume compressions immediately with a (standard) dose of epinephrine. Give the standard dose of epinephrine (0.01mg/kg administered IV or IO, 0.1 mg/kg if administered endotracheally) about every 3 to 5 minutes during cardiac arrest. If the rhythm continues to be "shockable," deliver a shock (4 J/kg), resume CPR immediately, and give amiodarone or lidocaine if amiodarone is not available while CPR is provided. Continue CPR for 5 cycles (about 2 minutes) before again checking the rhythm and attempting to defibrillate if needed with 4 J/kg. If defibrillation is successful but VF recurs, continue CPR while you give another bolus of amiodarone before you try to defibrillate with the previously successful shock dose. Search for and treat reversible causes. If there is an organized rhythm at any time, check for a pulse, if there is no pulse, treat it as pulseless electrical activity (PEA) and proceed accordingly (6).

Nonshockable Rhythm (Asystole / PEA)

The most common ECG findings in infants and children in cardiac arrest are asystole and PEA. PEA is organized electrical activity, most commonly slow, wide QRS complexes—without palpable pulses. For asystole and PEA: Resume high quality CPR and give standard dose of epinephrine after every 3 to 5 minutes. Search for and treat reversible causes

Tachycardia with Hemodynamic Instability

Because all arrhythmia therapies have the potential for serious adverse effects, consult an expert in pediatric arrhythmias before treating a hemodynamically stable child having tachycardia. If there are no palpable pulses, treat as pulseless arrest. If there is tachycardia on ECG monitor and pulses are palpable with patient having signs of hemodynamic compromise (poor perfusion, tachypnea, weak pulses), ensure ABC and assess QRS duration, determine if the QRS duration is d"0.09 second (narrow-complex tachycardia) or >0.09 second (wide-complex tachycardia) (6).

*Narrow-Complex (*d"*0.09Second) Tachycardia*

Differentiate between probable sinus tachycardia and probable supraventricular tachycardia on the basis of history and ECG findings (Table 4). If the rhythm is sinus tachycardia, search for and treat reversible causes. If it is probable supraventricular tachycardia attempt *vagal stimulation* (apply ice to the face without occluding the airway) while preparing for pharmacological or electrical cardioversion. Pharmacological cardioversion with adenosine (0.1 mg/kg) is very effective. If IV access is readily available administer adenosine using 2 syringes connected to a T-connector or stopcock; give adenosine rapidly with one syringe and immediately flush with >5 mL of normal saline with the other. If the patient is very unstable or IV access is not readily available, provide electrical (synchronized) cardioversion. Consider sedation if possible. Start with a dose of 0.5 to 1 J/kg.

If unsuccessful, repeat using a dose of 2 J/kg. If a second shock is unsuccessful or the tachycardia recurs quickly, consider antiarrhythmic therapy (amiodarone or procainamide) before a third shock. Consider obtaining expert consultation.

Wide-Complex (>0.09 Second) Tachycardia

Wide-complex tachycardia with poor perfusion is probably ventricular in origin but may be supraventricular with aberrancy. Treat with synchronized electrical cardioversion (0.5 J to 1 J/kg). If a second shock (2 J/kg) is unsuccessful or tachycardia recurs quickly, consider antiarrhythmic therapy (amiodarone or procainamide) before a third shock. If readily available, try a dose of adenosine to determine if the rhythm is SVT with aberrant conduction (6).

Table 4: Sinus Tachycardia and Supraventricular Tachycardia

Probable sinus tachycardia	Probable supraventricular tachycardia
• Compatible history consistent with known causes	• Vague and non-specific history, abrupt rate changes
• Normal P wave	• Abnormal or absent P wave
• Constant PR with variable RR	• Fixed heart rate
• Infants: rate usually <220	• Infants: rate usually =220
• Children: rate usually <180	• Children: rate usually =180

Other rhythm abnormalities

Bradycardia

If pulses, perfusion, and respirations are normal, no emergency treatment is necessary. If heart rate is <60 beats per minute with poor perfusion despite effective ventilation with oxygen, start chest compressions. Verify that the support is adequate and give standard dose of epinephrin. If bradycardia persists or responds only transiently, consider a continuous infusion of epinephrine or isoproterenol. If bradycardia is due to vagal stimulation, give atropine. Emergency transcutaneous pacing may be lifesaving if the bradycardia is due to complete heart block or sinus node dysfunction unresponsive to ventilation, oxygenation, chest compressions, and medications, especially if it is associated with congenital or acquired heart disease. Pacing is not useful for asystole or bradycardia due to post-arrest hypoxic/ ischemic myocardial insult or respiratory failure.

Torsades de Pointes

This polymorphic VT is seen in patients with a long QT interval, which may be congenital or may result from toxicity with antiarrhythmics, tricyclic antidepressants, digitalis, or drug interactions. Regardless of the cause, treat torsades de pointes with IV infusion of magnesium sulphate over several minutes.

Drug Therapy

Recommendations for drug therapy during pediatric resuscitation have changed significantly over the last 10 years. Several issues remain unresolved and recommen-dations may continue to change. See Table 5 for current dosing recommendations.

Oxygen

Most arrests occur as a result of tissue level hypoxia. It is therefore imperative that 100 percent oxygen be used throughout the resuscitation to minimize tissue hypoxia.

Epinephrine

After oxygen, epinephrine is widely considered to be the most effective drug in resuscitation. It is indicated for asystole, bradycardia, PEA, and ventricular fibrillation. Low-dose infusions (<0.3 ìg/kg per minute) generally produce â-adrenergic action (potent inotropy), and higher-dose infusions (>0.3 ìg/ kg per minute) cause á-adrenergic vasoconstriction (15). Because there is great interpatient variability titrate the drug to the desired effect (16).

Adenosine

It is very short acting antiarrhythmic drug with half life< 10 seconds so given as rapid push using two syringe technique. It is used for pharmacological cardioversion in supraventricular tachycardia. It briefly blocks conduction through AV node and depresses

Table 5: Common drugs used during resuscitation

Drug	Dose	Concentration	Comment
Atropine	0.02 mg/kg/dose	Range 0.1 mg to 1.2 mg/ml	Recommended minimum dose 0.1 mg, maximum dose 0.5 mg for a child
Adenosine	0.1 mg/kg IV/IO	3 mg/ml	Rapid bolus using two syringe technique
Dopamine	2-20 µg/kg/min	40, 80 and 160 mg/ml	Titrate to desired effect
Epinephrine	0.01 mg/kg/dose (IV/IO) 0.1mg/kg/dose of 1:1000 solution (endotracheally)	0.1 mg/ml (1:10,000)	High dose not recommended
Epinephrine (infusion)	0.1-1.0 µg/kg/min		Titrate to desired effect
Glucose	0.5 to 1 gm/kg/dose	D5W (0.05 gm/ml) D10W (0.1 gm/ml) D25W (0.25 gm/ml) D50W (0.5 gm/ml)	More important in neonates
Lidocaine	1 mg/kg/dose	10 & 20 mg/ml	Give bolus undiluted over 2-4 min.Repeat the bolus dose if > 15 minutes lapse before starting continuous infusion
Lidocaine infusion	20-50 µg/kg/min	(1 &2%)	
Amiodarone	5mg/kg over 20-60 mins max 15 mg/kg		Watch for hypotension if rapidly infused in 20 mins. Weigh the relative risks of arrhythmias and drug induced hypotension when it is administered.

sinus node automaticity. Recommended dose is 0.1 mg/kg IV/IO rapid bush (maximum dose 6 mg) as first dose and double the dose for second dose.

Amiodarone

It is class III antiarrhythmic agent used in treatment of ventricular fibrillation and pulseless ventricular tachycardia. Other indication are ventricular tachycardia with pulse and supraventricular tachycardia non responsive to cardioversion. Recommended dose is 5 mg/kg IV/IO load over 20 to 60 minutes (maximum dose 300 mg), repeat to maximum total dose of 15 mg/kg.

Glucose

Glucose is major energy substrate in the neonatal myocardium and they have limited glycogen stores. Consequently early assessment of a child's serum glucose and treatment of hypoglycemia is essential. Blind or repeated administration of glucose is not warranted as it may result in a hyperosmolar state (3).

Atropine

This is generally recommended for both asystole and bradycardia. Since bradycardia most commonly stems from hypoxia, atten-tion should be directed toward adequacy of airway and ventilation before atropine is given (3).

Sodium bicarbonate

Sodium bicarbonate does not find a place in routine resuscitation. It is indicated in management of hyperkalemia.

Calcium

No longer recommended in an arrest situation unless hypocalcemia is demonstrated or there is a specific therapeutic indication such as hy-perkalemia, hypermagnesemia, or calcium channel blocker overdose.

Lidocaine

Ventricular fibrillation or unstable tachycardia that does not respond to defibrillation is indications for the use of lidocaine. If one bolus dose is not effective, a repeat dose may be given in 10 to 15 minutes. Start a continuous infusion immediately. A third bolus may be needed 10 to 15 minutes later while the infusion is reaching steady-state concentrations.

Other drugs used during post resuscitation management

Dopamine

Titrate dopamine to treat shock that is unresponsive to fluid and when systemic vascular resistance is low. Typically a dose of 2-20 ìg/kg per minute is used. At doses(>5 ìg/kg per minute), dopamine stimulates cardiac beta-adrenergic receptors, but this effect may be reduced in infants and in chronic congestive heart failure.

Dobutamine

Dobutamine has a selective effect on $\hat{a}_1$ and $\hat{a}_2$ adrenergic receptors; it increases myocardial contractility and usually decreases peripheral vascular resistance. Titrate an infusion to improve cardiac output and blood pressure, especially due to poor myocardial function.

Norepinephrine

Norepinephrine is a potent inotropic and peripheral vasoconstricting agent. Titrate an infusion to treat shock with low systemic vascular resistance (septic, anaphylactic, spinal, or vasodilatory) unresponsive to fluid.

Sodium Nitroprusside

Sodium nitroprusside increases cardiac output by decreasing vascular resistance (afterload). If hypotension is related to poor myocardial function, consider using a combination of sodium nitroprusside to reduce afterload and an inotrope to improve contractility.

Inodilators

Inodilators (inamrinone and milrinone) augment cardiac output with little effect on myocardial oxygen demand. Use an inodilator for treatment of myocardial dysfunction with increased systemic or pulmonary vascular resistance. Administration of fluids may be required because of the vasodilatory effects. Inodilators have a long half-life with a long delay in reaching a new steady-state hemodynamic effect after changing the infusion rate. In case of toxicity, if you stop the infusion the adverse effects may persist for several hours.

Guidelines for Stopping Resuscitation Efforts

There are no established standards for terminating resuscitative efforts in an emergency setting. Patients with unwitnessed cardiopulmonary arrest or delay of greater than 12 minutes before cardiopulmonary resuscitation (CPR) is initiated, have a poor prognosis (17). Children presenting with asystole do much worse than do children presenting with other types of rhythm (1). Children who develop sinus rhythm and perfusion after more than two doses of

epinephrine also have low long-term survival (18). The exception is children who are hypothermic, most commonly from cold-water drown-ing. Establishing brain death by strict criteria takes time and is impossible to do in an emergency setting.

Based on this set of facts, it is reasonable to intubate, ventilate, and perform compressions on all children who present in cardiopulmonary arrest until their hypoxia and respiratory acidosis is reversed, their core temperature is raised to 35°C, and they have been given at least two doses of epinephrine and *as indicated* counter shocked or given drugs such as glucose. Resuscitative efforts should be continued on children who intermittently restore perfusion or demonstrate supraventricular tachy-cardia or a ventricular rhythm. Regardless of the duration of suspected anoxia, any child who restores perfusion should continue to be treated. Though the prognosis for some of these children will be poor, termination can only be medico-legally carried out in hospital setting and should not be terminated in the field. Resuscitation can be stopped on children who remain unresponsive without pulse and rhythm after the resuscitative efforts outlined above have been completed (19).

Conclusions

Survival rates from cardiopulmonary resuscitation in children are low. Hence vigilant monitoring of children with potentially fatal diseases is essential. Early intervention prior to arrest will result in the highest possible rates of recovery. Since all cardiopulmonary arrests are not completely preventable, however, the highest survival rates will result from prompt, well-organized resuscitative efforts. Current guidelines for CPR recommend compression first followed by management of airway and breathing to promptly start CPR without losing precious time in airway management and to encourage bystander CPR for children in case of out of hospital cardiac arrest.

The physiology and pharmacology of cardiopulmonary resuscitation are evolving sciences. Changes in approach and outcome can be expected to continue to occur over the next decade.

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Figure 1: Supraventricular tachycardia

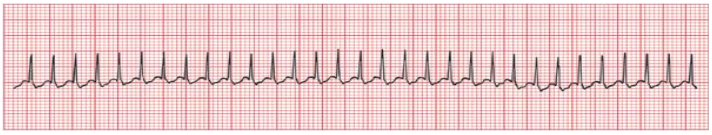

Figure 2: Ventricular Tachycardia

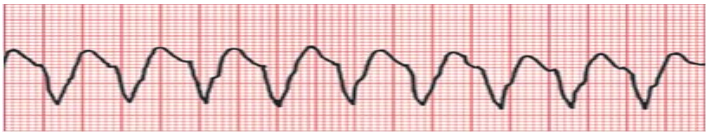

Figure 3: Ventricular Fibrillation

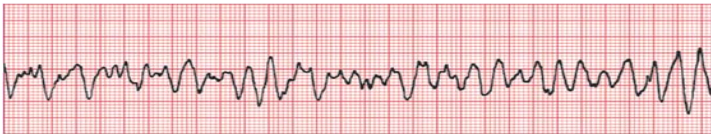

Figure 4: Torsades de Pointes