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Articles

Pediatric Resuscitation

An Advisory Statement From the Pediatric Working Group of the International Liaison Committee on Resuscitation

Writing Group

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Purpose

This summary document reflects the deliberation of the Pediatric Working Group of the International Liaison Committee on Resuscitation (ILCOR). The ILCOR goal is to improve consistency of guidelines issued by international resuscitation councils and associations. The purpose of this summary is to highlight areas of conflict or controversy in current pediatric basic and advanced life support guidelines,[1 2 3 4 5] outline solutions considered, and provide recommendations reached by consensus of the working group. Unresolved issues are listed and a few areas of active guideline research interest and investigation are highlighted. This document does not include a complete list of guidelines for which there is no perceived controversy. The algorithm/decision tree figures presented attempt to illustrate a common flow of assessments and interventions. Whenever possible, this was coordinated to complement the basic life support (BLS) and advanced life support (ALS) algorithms used for adult victims. Since arrest of the newly born infant presents unique resuscitation challenges in terms of etiology, physiology, and required resources, the working group developed a separate section addressing initial resuscitation of the newly born. Other areas of departure from the adult algorithms are noted and the rationale explained in text.

In the absence of specific pediatric data (outcome validity), recommendations may be made or supported on the basis of common sense (face validity) or ease of teaching or skill retention (construct validity). Practicality of recommendations in the context of local resources (technology and personnel) and customs must always be considered. In compiling this document, it was surprising to the working group participants how few differences exist among current pediatric guidelines advocated by the American Heart Association, the Heart and Stroke Foundation of Canada, the European Resuscitation Council, the Australian Resuscitation Council, and the Resuscitation Councils of Southern Africa.

Background

The epidemiology and outcome of pediatric cardiopulmonary arrest and the priorities, techniques, and sequence of pediatric resuscitation assessments and interventions differ from those of adults. As a result, it is imperative that any guidelines developed for pediatric resuscitation address the unique needs of the newly born, infant, child, and young adult. Unfortunately, specific data supporting these differences have been deficient in both quantity and quality for several reasons: (1) pediatric cardiac arrest is uncommon, (2) in most circumstances survival from documented asystolic pediatric cardiac arrest is dismal, and (3) most pediatric studies have failed to utilize consistent patient inclusion criteria and resuscitation outcome definitions and measures. Additional specific pediatric data including data for the newly born are required to confirm or further refine pediatric resuscitation techniques.

In general, prehospital primary cardiac arrest is a less common etiology of arrest in children and young adults than in older adults,[6 7 8] and primary respiratory arrest appears to be a more common etiology than primary cardiac arrest in children.[9 10 11 12 13] However, most reports of pediatric arrest contain insufficient patient numbers or utilize exclusion criteria that prohibit broad generalization of study results to general or international pediatric populations. In a 15-year retrospective study of prehospital cardiac arrest from the United States, only 7% of 10 992 victims of prehospital cardiac arrest were younger than 30 years, and only 3.7% were younger than 8 years.[6] Only 2% of victims of in-hospital cardiopulmonary resuscitation (CPR) in Great Britain were 0 to 14 years of age.[14]

Cardiac arrest in children is rarely sudden; it is typically the end result of deterioration in respiratory function or shock, and the terminal rhythm is typically bradycardia with progression to pulseless electrical activity or asystole.[15 16] Ventricular tachycardia and fibrillation have been reported in 15% or less of a subset of pediatric and adolescent victims of prehospital cardiac arrest,[6 7] even when rhythm is assessed by first responders.[17 18]

Survival following prehospital cardiopulmonary arrest averages only approximately 3% to 17% in most studies, and survivors are often neurologically devastated.[7 9 10 11 15 17 18 19 20 21 22 23] In addition, most pediatric resuscitation reports are retrospective in design and plagued with inconsistent resuscitation definitions and patient inclusion criteria. As a result, conclusions based upon statistical analysis of the efficacy of specific resuscitative efforts are unreliable. Some of these problems should be improved by application of uniform guidelines for reporting outcomes of ALS interventions outlined in the pediatric Utstein-style guidelines.[24] Large, randomized multicenter and multinational clinical trials are clearly needed.

Age Definitions: What Defines an Infant, Child, and Adult?

The age of the victim is currently the primary characteristic that guides decisions for application of resuscitation sequences and techniques. Discrimination on the basis of age alone is inadequate. Further, any single age delineation of the "child" versus the "adult" is arbitrary because there is no single parameter that separates the infant from the child from the adult. The following factors should be considered.

Anatomy

There is consensus that the age cut-off for infants should be at approximately 1 year. In general, cardiac compression can be accomplished using one hand for victims up to the age of approximately 8 years. However, variability in the size of the victim or the size and strength of the rescuer can require use of the two-handed "adult" compression technique for cardiac compression. For instance, the chronically ill infant may be sufficiently small to enable compression using circular hand technique, and a 6- or 7-year-old may be too large for the one-hand compression technique. A small rescuer may need to use two hands to effectively compress the chest of a child victim.

Physiology

The newly born provide an example of how physiological considerations may affect resuscitative interventions. Perinatal circulatory changes during transition from fetus to newborn may result in profound extrapulmonary shunting of blood. Fluid-filled alveoli may require higher initial ventilation pressures than subsequent rescue breathing. Lung inspiratory and expiratory time constants for filling and emptying and inflation volumes may need to be adjusted according to both anatomic and physiological development.

Epidemiology
Ideally the sequence of resuscitation should be determined by the most likely cause of the arrest. In the newly born infant this will be most likely related to respiratory failure. In the older infant and child it may be related to progression of respiratory failure, shock, or neurological dysfunction. In general, pediatric prehospital arrest has been characterized as hypoxic, hypercarbic arrest with respiratory arrest preceding asystolic cardiac arrest.[10 25 26] Therefore, a focus on early ventilation and early CPR (rather than early emergency medical services [EMS] activation and/or defibrillation) appears to be warranted. Early effective oxygenation and ventilation must be established as quickly as possible. Primary dysrhythmic cardiac arrest may occur and should particularly be considered in patients with underlying cardiac disease or history consistent with myocarditis.

Resuscitation Sequence/EMS Activation
Local response intervals, dispatcher training, and EMS protocols may dictate the sequence of early life support interventions. In addition, the sequence of resuscitation actions must consider the most likely causes of arrest in the victim. Respiratory failure and/or trauma may be the primary etiologies of cardiopulmonary arrest in victims aged 40 years or younger,[6 8] with a relatively low incidence of primary ventricular fibrillation (VF). One critical issue in determining the sequence of interventions is whether the primary cause of arrest is due to a cardiac or respiratory etiology. The probability of successful resuscitation based on that etiology is another important unresolved resuscitation question.

Pediatric BLS

Determination of Responsiveness
Unresponsiveness mandates assessment and support of airway and breathing. Infants and patients with suspected cervical spinal injury should not be shaken to assess responsiveness.

Airway
Consensus continues to support use of the head tilt–chin lift or the jaw thrust (the jaw thrust especially when cervical spine instability or neck trauma is suspected) to open the airway. Other maneuvers, such as the tongue–jaw lift, may be considered if initial ventilation is unsuccessful despite repositioning of the head. The most common cause of airway obstruction in the unconscious pediatric victim is the tongue.[27] Although the use of a tongue–jaw lift and visual mouth inspection prior to ventilation of any unconscious infant may be considered if foreign body airway obstruction is strongly suspected, there are no data to support the delay of attempted ventilation in all victims. Blind removal or attempted visualization of unsuspected foreign bodies is not likely to be effective for the following reasons: foreign bodies causing complete airway obstruction are unlikely to be visible with cursory inspection, the object may not be retrievable, and attempted intervention may result in displacement of the object further into the trachea. More data are needed regarding the optimal method of keeping the airway open to ensure effective ventilation during CPR.

Breathing
There is general consensus regarding the technique for rescue breathing for infants and children. The current recommendations for initial number of attempted breaths, however, vary from 2 to 5.[1 2 3 4 5] There are no data to support any specific number of initial breaths. There was agreement that a minimum of 2 breaths be attempted. The rationale for attempting to deliver more than 2 initial ventilations includes the need to provide effective ventilation for pediatric victims based upon the likely hypoxic and hypercarbic etiology of arrest, suspected inability of the lay rescuer to establish effective ventilation with only 2 attempts, and clinical impressions that more than 2 breaths may be required to improve oxygenation and restore effective heart rate in the apneic, bradycardic infant.

Initial breaths should be delivered slowly, over 1.0 to 1.5 seconds, with a force sufficient to make the chest clearly rise. Care and attention to abdominal distention caused by insufflation of gas into the stomach should be recognized and avoided.[28 29 30]

Consideration of the optimal method for delivering breaths to infants supports the current recommendation of mouth to mouth-and-nose ventilation for infants up to 1 year old. However, mouth-to-nose ventilation may be adequate in this population.[31 32]

Consensus continues to support the emphasis on the provision of more ventilation (breaths per minute) for infants and children and more compressions per minute for adult victims. Current recommended ventilation rates are based on normal ventilatory rates for age, the need for coordination with chest compression, and the perceived practical ability of the rescuer to provide them (See Fig 1). Ideal ventilation frequency during CPR is unknown.

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Figure 1. Comparison of resuscitative interventions for newborns, infants, children, and adults. CPR indicates cardiopulmonary resuscitation; EMS, emergency medical services; BLS, basic life support; and ALS, advanced life support. *Interventions recommended *for suitably trained healthcare providers only.*

Circulation

There is a lack of specific pediatric data on the accuracy and time course for determining pulselessness of victims who are apneic and unresponsive. Several reports have documented the inability of lay rescuers and healthcare providers to reliably locate or count the pulse of the victim.[33 34] The utility of the pulse check during pediatric CPR has been questioned.[35] Furthermore, the pulse check is difficult to teach to laypersons. It seems reasonable for healthcare providers to search for a pulse because it may be palpated by trained personnel, does not require sophisticated equipment, and there is no better alternative. However, resuscitative interventions should *not* be delayed beyond 10 seconds if a pulse is not confidently detected.

Chest Compression

When to Start

There is consensus that all pulseless patients and patients with heart rates too low to adequately perfuse vital organs warrant chest compressions. Because cardiac output in infancy and childhood is largely heart-rate dependent, profound bradycardia is usually considered an indication for cardiac compressions.

Location of Compression

There is consensus for compression over the lower half of the sternum, taking care to avoid compression of the xiphoid.

Depth

Consensus supports recommendation of relative rather than absolute depth of compression (eg, compress approximately one third of the depth of the chest rather than compress 4 to 5 cm).

Effectiveness of compression should be assessed by the healthcare provider. Methods of assessment include palpation of pulses, evaluation of end-tidal carbon dioxide, and analysis of arterial pressure waveform (if intra-arterial monitoring is in place). Although it is recognized that pulses palpated during chest compression may reflect venous rather than arterial blood flow during CPR,[36] pulse detection during CPR for healthcare providers remains the most universally practical "quick assessment" of chest compression efficacy.

Rate

Consensus supports a rate of approximately 100 compressions per minute. With interposed ventilations, this will result in the actual delivery of <100 compressions to the patient in a 1-minute period.

Compression-to-Ventilation Ratio

Ideal compression-ventilation ratios for infants and children are unknown. A single, universal compression-ventilation ratio for all ages and both BLS and ALS interventions would be desirable from an educational standpoint. There currently is consensus among resuscitation councils for a compression-ventilation ratio of 3:1 for newborns and 5:1 for infants and children. The justification for this difference from adult guidelines includes (1) the fact that respiratory problems are the most common etiology of pediatric arrest and therefore ventilation should be emphasized, and (2) physiological respiratory rates of infants and children are faster than those of adults. Although the actual number of delivered interventions is dependent on the amount of time the rescuer spends opening the airway and the effect of frequent airway repositioning on rescuer fatigue, there is insufficient evidence to justify changing the current recommendations for educational convenience at this time.

External chest compression must always be accompanied by rescue breathing in children. At the end of every compression cycle a rescue breath should be given. Interposition of compressions and ventilations is recommended to avoid simultaneous compression/ventilation.

Activation of the EMS System

Ideally the sequence of resuscitation is determined by the etiology of the arrest. In pediatric arrest, dysrhythmias requiring defibrillation are relatively uncommon, and some data suggest that early bystander CPR is associated with improved survival.[9 36 37] However, it is impractical to teach the lay public different resuscitation sequences based on arrest etiology. The consensus recommendation is "phone fast" rather than "phone first" for young victims of cardiac arrest, but the appropriate age cut-off for this recommendation remains to be determined. Local EMS response intervals and the availability of dispatcher-guided CPR may override these considerations.

Recovery Position

Although many recovery positions are used in the management of pediatric patients, particularly in those emerging from anesthesia, no specific optimal recovery position can be universally endorsed on the basis of scientific study in children. There is consensus that an ideal recovery position considers the following: etiology of the arrest and stability of the C-spine, risk for aspiration, attention to pressure points, ability to monitor adequacy of ventilation and perfusion, maintenance of a patent airway, and access to the patient for interventions.

Relief of Foreign-Body Airway Obstruction

Consensus supports prompt recognition and treatment of complete airway obstruction. There are three suggested maneuvers to remove impacted foreign bodies: back blows, chest thrusts, and abdominal thrusts. The sequences differ slightly among resuscitation councils, but published data do not convincingly support one technique sequence over another. There is consensus that the lack of protection of the upper abdominal organs by the rib cage renders infants and newborns at risk for iatrogenic trauma from abdominal thrusts; therefore, abdominal thrusts are not recommended in infants and newborns. An additional practical consideration is that back blows should be delivered with the victim positioned head down, which may be physically difficult in older children. Suctioning is recommended for newborns rather than back blows or abdominal thrusts, which are potentially harmful to this age group.

Barrier Equipment

Healthcare professionals should utilize appropriate barrier devices and universal precautions whenever possible. However, issues related to efficacy of the devices in preventing bacterial or viral transmission, anatomical fit of masks, use of devices in pediatric patients with increased airway resistance and dead space ventilation, and the actual risk for pediatric disease transmissibility during pediatric resuscitative interventions are not resolved.

Pediatric ALS

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Automated External Defibrillators in Pediatrics

The true prevalence of VF among pediatric victims of cardiopulmonary arrest is unknown. Early rhythm assessment for pediatric prehospital arrest is not frequently reported or reliable. In most studies, pulseless ventricular tachycardia (VT) or VF has been documented in less than 10% of all pediatric arrest victims,[6,15,16,17,38] even when the victim was evaluated by first responders within 6.2 minutes of EMS call.[7,18] In some studies, VF treated with early defibrillation, both at the scene and in the hospital, may result in better survival rates than asystole or electromechanical dissociation.[20] However, other studies contradict these data.[17,18] The development of automated external defibrillators (AEDs) has not yet addressed the energy levels required to treat VT or VF in children or the reliability of these devices in the detection of VT and VF in children. The age-appropriate application of AEDs is assumed to be similar to current guidelines for initial defibrillator placement and energy delivery. Therefore, the conditions under which early detection and treatment of VF should be emphasized requires further research.

Vascular Access

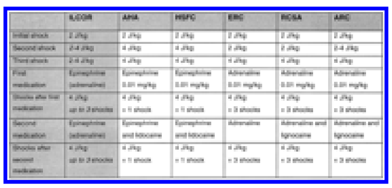
Vascular access for the arrested victim is needed for the delivery of resuscitative fluids and medications. However, establishment of adequate ventilation with BLS support of circulation is the first priority. The intravenous or intraosseous route for the delivery of medications is the preferred route,[39,40,41,42,43] but the endotracheal route can be used in circumstances when vascular access is delayed. It is likely that drug delivery following endotracheal epinephrine administration may be lower than that delivered by the intravascular approach. Drug doses may need to be increased accordingly, with attention to drug concentration, volume of vehicle, and delivery technique.[44,45,46,47] There is consensus that the tibial intraosseous route is useful for vascular access, particularly for victims up to the age of 6 years.[48,49] In the newly born, the umbilical vein is easy to find and frequently used for urgent vascular access.

Dose of Epinephrine

Consensus supports the initial dose of epinephrine (adrenaline) at 0.01 mg/kg (0.1 mL/kg of the 1:10 000 solution) by an intravascular route or 0.1 mg/kg (0.1 mL/kg of the 1:1000 solution) by the endotracheal route. Because the outcome of asystolic and pulseless arrest in children is very poor and a beneficial effect of higher doses of epinephrine has been suggested by some animal studies and a single retrospective pediatric study,[50,51,52,53,54] second and subsequent intravenous doses and all endotracheal doses for unresponsive asystolic and pulseless arrest in infants and children should be 0.1 mg/kg (0.1 mL/kg of the 1:1000 solution) as a Class IIa recommendation. If no return of spontaneous circulation occurs beyond the second dose of epinephrine despite adequate CPR, the outcome is likely to be dismal.[11] [17] [21] High-dose epinephrine is of special concern for patients with high risk for intracranial hemorrhage, such as the preterm newborn. Disappointing efficacy of high-dose epinephrine when used in adult study populations[55] [56] and the potential detrimental effects of high-dose epinephrine therapy, including the potential for systemic and intracranial hypertension (particularly in the newborn), myocardial hemorrhage, or necrosis[57] [58] suggest caution in advocating high-dose epinephrine therapy unless further study is encouraging.

Sequence of Defibrillatory Shocks and Medications for Ventricular Fibrillation

VF and pulseless VT are relatively uncommon in infants and children. Although there are minor differences between the names of the drugs, dose of second defibrillation, and number of defibrillations between medication doses (see Fig 2) based on local availability and custom, there is general consensus on medication/defibrillation dosage and sequence for VF/pulseless VT. The initial treatment is defibrillation with 2 J/kg increasing to a maximum of 4 J/kg in a series of three shocks. Subsequent series of up to three shocks following medication administration is based on local custom and training (ie, first defibrillation up to three times [2 J/kg, 2 to 4 J/kg, 4 J/kg], then medication with adrenaline/epinephrine and circulation, then defibrillation up to three times [4 J/kg], then repeat adrenaline/epinephrine at higher dose, then defibrillation up to three times [4 J/kg] and consideration for other medications [lignocaine/lidocaine] and the treatment of reversible causes) (see universal pediatric template, Figs 3 and 4).



	ILCOR	AHA	HSFC	ERC	RCSA	ARC
Initial shock	2 J/kg	2 J/kg	2 J/kg	2 J/kg	2 J/kg	2 J/kg
Second shock	2-4 J/kg	4 J/kg	4 J/kg	2 J/kg	2 J/kg	2-4 J/kg
Third shock	2-4 J/kg	4 J/kg	4 J/kg	4 J/kg	4 J/kg	4 J/kg
First medication	Epinephrine (adrenaline)	Epinephrine 0.01 mg/kg	Epinephrine 0.01 mg/kg	Adrenaline 0.01 mg/kg	Adrenaline 0.01 mg/kg	Adrenaline 0.01 mg/kg
Shocks after first medication	4 J/kg up to 3 shocks	4 J/kg × 1 shock	4 J/kg × 1 shock	4 J/kg × 3 shocks	4 J/kg × 3 shocks	4 J/kg × 3 shocks
Second medication	Epinephrine (adrenaline)	Epinephrine and lidocaine	Epinephrine and lidocaine	Adrenaline	Adrenaline and lignocaine	Adrenaline and lignocaine
Shocks after second medication	4 J/kg up to 3 shocks	4 J/kg × 1 shock	4 J/kg × 1 shock	4 J/kg × 3 shocks	4 J/kg × 3 shocks	4 J/kg × 3 shocks

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Figure 2. Examples of minor differences in recommendations for treatment of ventricular fibrillation and pulseless ventricular tachycardia between the International Liaison Committee on Resuscitation (ILCOR), the American Heart Association (AHA), the Heart and Stroke Foundation of Canada (HSFC), the European Resuscitation Council (ERC), the Resuscitation Councils of Southern Africa (RCSA), and the Australian Resuscitation Council (ARC).

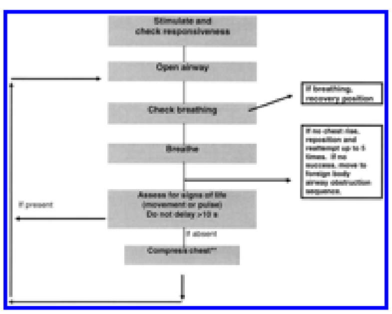

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Figure 3. Universal pediatric basic life support (BLS) template for lay rescuers. **Continue rescue breathing and cardiopulmonary resuscitation as indicated. Activate emergency medical services as soon as possible, based on local and regional availability.

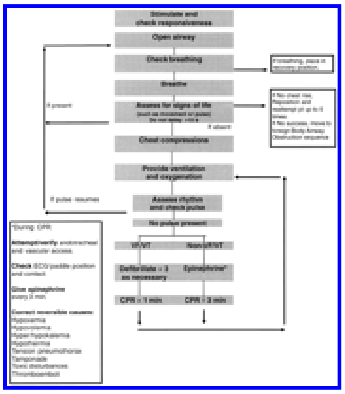

Figure 4. Universal pediatric template for pediatric healthcare providers. VF indicates ventricular fibrillation; VT, ventricular tachycardia; defib, defibrillation; CPR, cardiopulmonary resuscitation; and ECG, electrocardiogram.

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Complications From CPR

Reported complications from appropriately applied resuscitative techniques are rare in infants and children. The prevalence of significant adverse effects (rib fractures, pneumothorax, pneumoperitoneum, hemorrhage, retinal hemorrhages, etc) from properly performed CPR appears to be much lower in children than in adults.[59 60 61 62 63 64 65 66] In the most recent study,[59] despite prolonged CPR by rescuers with variable resuscitation training skill levels, medically significant complications were documented in only 3% of patients. Therefore, there is consensus that chest compressions should be provided for children if the pulse is absent or critically slow or if the rescuer is uncertain if a pulse is present.

Guidelines for the Newly Born

There is a need for international guidelines on BLS for newborns. A review of information from the US national database, the World Health Organization, and Seattle/King County EMS systems[67] demonstrates the importance of developing an early intervention sequence for the newly born. In the United States, approximately 1% of births occur in out-of-hospital facilities, but neonatal mortality is more than double for these children born out of hospital. Worldwide, more than 5 million newborn deaths occur, with approximately 56% of all births out of facility. Neonatal mortality is high, with birth asphyxia accounting for 19% of these deaths. These data are only for mortality; the morbidity from asphyxia and inadequate newborn resuscitation must be assumed to be much higher. The worldwide potential for lives saved from newborn asphyxia with simple airway interventions is estimated at more than 900 000 infants per year. Therefore, the consensus supports guidelines from ILCOR for the newly born as a worthy goal.

Although the following are intended as preliminary BLS advisory guidelines, the difference between BLS and ALS interventions for the newly born may be subtle. The development of specific ILCOR advisory guidelines for newborn ALS is beyond the scope of this document. It is hoped that ILCOR member organizations will address newborn ALS in the near future. In the newborn, because birth can usually be anticipated, it is often possible to have more personnel and equipment on hand than may be available for unexpected BLS interventions in older children or adults. Ideally, the mother should give birth in a location with optimum equipment available and personnel trained in newborn resuscitation. If this is not possible, then certain rudimentary equipment should be available at the birthsite or should be brought to the birth attendant. Such equipment might include the following:

- Bag-valve–mask ventilation device of appropriate size for the newborn
- Suction device
- Warm, dry towels and blanket
- Clean (sterile, if possible) instrument for cutting the umbilical cord

- Clean rubber gloves for the attendant

Most newly born infants will breathe spontaneously (usually manifested by a cry) within seconds after birth. During this time, an attendant should dry the newborn with a warm towel and remove wet linen to reduce heat loss. If the baby is limp and not crying, immediate resuscitation is required.

BLS for the Newly Born

(See Fig 5, universal newborn template)

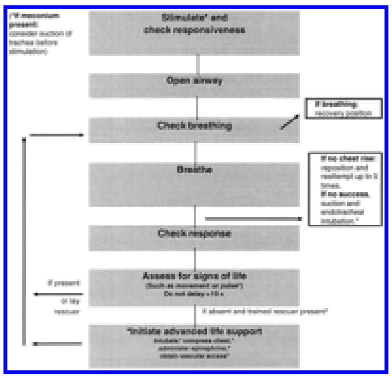

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Figure 5. Universal newborn (newly born) template. *Advanced life support interventions recommended *for suitably trained healthcare providers only: pulse check, chest compressions, endotracheal suction and intubation, vascular access, and epinephrine administration*.

1. Stimulate and check responsiveness.

a. Stimulation is best provided by drying the newborn with a towel and flicking the soles of the feet. Slapping, shaking, spanking, or holding the newborn upside down is contraindicated and potentially dangerous.

b. Assess for a cry: A cry is the most common confirmation of adequate initial ventilation. If present, further resuscitative efforts are probably not indicated.

c. Assess for regular respirations: Although the respiratory pattern may be irregular, respirations should be sufficient to result in adequate oxygenation (ie, absence of persistent central cyanosis). Occasional "gasping," without normal breaths interspersed, is generally indicative of severe compromise and should be treated as inadequate respiration. If poor response, call or send for additional assistance.

2. Open airway.

a. Clear the airway of material, particularly if blood or meconium is present. This has special importance in the newborn because of the narrow airway, which creates high resistance to gas flow. Clearing the airway will also provide additional respiratory stimulation. Clearing of secretions should be accomplished with a suction device (bulb syringe, suction catheter); otherwise, removal of secretions may be accomplished with a cloth wrapped around the rescuer's finger.

b. Position the head to the "sniffing" position and particularly avoid excessive neck flexion or hyperextension, which may result in airway obstruction.

c. *If a suitably trained provider and equipment are available:* if the newly born is stained with thick meconium, the trachea should be suctioned as the initial resuscitative step. This is accomplished by intubating the trachea, applying suction directly to the tube using any of a variety of devices available for this purpose, and withdrawing the tube as suction is continued. If meconium is recovered, it may be necessary to repeat this procedure several times until the residual is sufficiently thin to permit suctioning through the tube using a standard suction catheter.

3. Check breathing.

a. Assess for presence of a cry. If a strong cry is present, further resuscitation efforts are not indicated. If the cry is weak or absent: look, listen, and feel for air entry and chest movement and feel for evidence of spontaneous respiration.

b. If respirations are absent or inadequate (gasping), assisted ventilation is necessary. Further attempts to stimulate the newborn in this case will waste valuable time.

4. Breathe.

a. Although it is recognized that a bag-valve mask is the most effective piece of equipment for assisting ventilation, various other devices are available or are being developed. Use will be dictated by local availability, cost, and custom.

b. If a resuscitation device is not available, consider using mouth to mouth-and-nose to assist ventilation. Although some controversy exists about whether a mother's mouth can effectively seal her older infant's mouth and nose,[31] [32] consensus supports initial attempts at newborn ventilation via both the infant's mouth and nose. Because of the presence of maternal blood and other body fluids on the face of the newborn, there is a perceived risk of infection to the rescuer. Quickly wipe away as much of this material as possible before attempting mouth to mouth-and-nose ventilation.

c. Blow sufficient air into the newborn airway to cause the chest to rise visibly.

d. Watch for chest rise as an indication of ventilation efficacy. If inadequate, adjust head position, clear airway, achieve a seal over the mouth and nose on the face, and consider an increase in inflation pressure.

e. Ventilate at a rate of approximately 30 to 60 times per minute.

f. Note that *initial* breaths may require a higher inflating pressure to overcome the resistance in small and fluid-filled airways.

5. Assess response.

a. After assisting ventilation for 30 seconds to 1 minute, check again for response. If still no response, deliver breaths, watching closely for adequate chest rise with each delivered breath.

b. In addition to the presence of a cry and spontaneous respirations, the response may also be assessed by feeling for a pulse, although this may be difficult in the newborn and should not distract the rescuer from providing adequate ventilations. A pulse may be detectable by feeling the base of the umbilical cord and should be >100 beats per minute (bpm).

c. Continue to ventilate and assess (return to step 2) until there is either an adequate response (crying, breathing, and heart rate >100 bpm), or additional medical assistance has arrived. If effective spontaneous respirations resume, consider positioning the newborn on its side in a recovery position.

6. Compress chest.

a. Laypersons: Chest compressions in the newborn are not recommended for administration by persons untrained in neonatal resuscitation, particularly when rescue is being provided by a single individual. Ventilation is nearly always the primary need of the newly born, and administration of chest compressions may decrease the efficacy of assisted ventilation.[68]

b. Trained healthcare providers: If suitably trained healthcare providers are available and adequate ventilations have not resulted in improvement, the following steps should be taken:

1. Feel for a pulse. In the newborn, a pulse is most easily palpated by lightly grasping the base of the umbilical cord between the thumb and index finger. If a stethoscope is available, a heartbeat may be detected by auscultating the chest.

2. Assess the heart rate for up to 10 seconds. If the heart rate is <60 bpm and not clearly rising, begin chest compressions. If the heart rate is >60 and rising, consider continuing effective ventilations alone and reassess the heart rate in 60 seconds.

3. Chest compressions for the newborn are delivered in series of three, followed by a pause for delivery of a ventilation (ratio: 3 compressions and 1 ventilation per cycle). The rate should be approximately 120 "events" (ie, -c-c-c-v-c-c-c-v-) per minute.

4. Reassess the heart rate approximately every 60 seconds, until the heart rate improves to >60 to 80 bpm or ALS resources are available for oxygen supplementation, endotracheal intubation, and administration of epinephrine.

7. Other newborn issues

a. Temperature control: In addition to drying the newborn to decrease evaporative heat loss, drape the baby in dry towels or a blanket during the resuscitation process. Remove the newborn from wet surfaces or pools of fluid. As soon as resuscitation has been successful, place the baby skin-to-skin on the mother's chest/breast and cover both with a blanket.

b. Infection control: Wash hands and wear gloves, using universal precautions for secretion contact, if available. Use clean towels, blankets, and instruments and avoid rescuer exposure to blood and other fluids.

c. Umbilical cord: It is not necessary to cut the umbilical cord before resuscitation of the newborn. The umbilical cord can be cut after the baby is spontaneously breathing and the cord has stopped pulsating. The cutting instrument and cord ties should be sterilized, if possible. These may be sterilized by boiling in water for 20 minutes. A new packaged razor blade does not require sterilization. If sterile equipment is not available, clean equipment should be used. Tie the cord in two places with a string. Cut the cord between the ties with a razor blade, scissors, or knife.

d. Do not forget the mother. Watch for and attend to potential complications of childbirth. Excessive vaginal bleeding, seizures, and infection are the most common maternal complications of childbirth. Arrange for healthcare provider support to attend to mother and child, if possible.

Research

The paucity of pediatric and newborn clinical resuscitation outcome data makes scientific justification of recommendations difficult. Therefore, the development of prospective, pediatric-specific clinical studies and the development of laboratory and animal resuscitation models that specifically address pediatric and neonatal issues is of paramount importance. Collection of data should follow the pediatric Utstein-style guidelines.[24] [69] Specific data on the etiology of arrest, success of interventions, frequency and severity of complications, significant short- and long-term neurological and overall performance outcomes, educational value, and costs associated with resuscitation techniques are urgently needed.

Areas of Controversy, Unresolved Issues, and Need for Additional Research

The ILCOR pediatric working group recognizes the difficulty in creating advisory statements for universal application. After careful review of the rationale for current guidelines that exist in North America, Europe, Australia, and Southern Africa, the working group identified the areas of controversy where it was thought the greatest need for research exists before evolution to universal guidelines can occur.

Some of these areas are listed below.

1. Should initial resuscitation interventions and sequences be based on etiology of arrest or the likelihood of successfully resuscitating a presenting cardiac rhythm (eg, etiology: hypoxia/asystole most likely for children but VF treated with defibrillation most likely to have successful resuscitation)?

2. What is the prevalence of VF during or following resuscitation?

3. What number of breaths should be initially attempted after opening the airway? (AHA/Heart and Stroke Foundation of Canada: 2 breaths; European Resuscitation Council: 5 breaths; Australian Resuscitation Council: 4 breaths; Resuscitation Councils of Southern Africa: 2 breaths; ILCOR: 2 to 5 breaths.)

4. Is adult mouth to infant nose ventilation a better method than adult mouth to infant mouth-and-nose ventilation for newborns and/or infants?

5. What sequence of interventions for the conscious choking child is most appropriate: back blows versus abdominal thrusts versus chest thrusts, and should visual inspection of the mouth for foreign body precede attempts at ventilation in infants?

6. What is an optimal recovery position for infants and children?

7. At what heart rate should chest compressions be initiated in ALS: when the pulse is absent or "too slow"? (Currently: AHA/Heart and Stroke Foundation of Canada: <60 bpm; European Resuscitation Council: <60 bpm; Australian Resuscitation Council: 40 to 60 bpm; Resuscitation Councils of Southern Africa: <60 bpm; ILCOR: <60 bpm.)

8. What is the optimal depth for chest compressions? (One third to one half depth of chest or a specified number of inches or centimeters. ILCOR: Approximately one third the depth of the chest.)

9. What is an optimal compression-ventilation ratio for different age groups, and can a universal compression-ventilation ratio be adopted that accommodates all victims from newborn to adult?

10. What is the appropriate dose of epinephrine? (ILCOR: First dose of adrenaline/epinephrine, 0.01 mg/kg, subsequent doses, 0.1 mg/kg.)

11. What defibrillation dose and how many defibrillation shocks should be delivered after medication for VF in children? (ILCOR: 2 J/kg, 2 to 4 J/kg, 4 J/kg; 1 to 3 shocks at 4 J/kg after medications.)

12. Should alternative medications (eg, lidocaine/lignocaine) be used for persistent VF if defibrillation and initial epinephrine dose are not successful?

13. Can AEDs accurately and reliably be used for pediatric patients?

14. What is the role of alkalyzing agents in the arrested patient who is suspected of having severe acidosis?

15. What is the role of transcutaneous (external) pacing in the resuscitation of pediatric patients without an organized cardiac rhythm?

16. What sequence of interventions should be employed by advanced healthcare providers for the newborn?

17. What is the effect of implementing ILCOR guidelines on arrest prevention, resuscitation rates, and neurological outcomes from cardiopulmonary arrest in newborns, infants, and children?

The epidemiology and outcome of pediatric cardiopulmonary arrest and the priorities, techniques, and sequence of pediatric resuscitation assessments and interventions differ from those of adults. The pediatric working group was surprised by the degree of conformity already existing in current guidelines advocated by the American Heart Association, the Heart and Stroke Foundation of Canada, the European Resuscitation Council, the Australian Resuscitation Council, and the Resuscitation Councils of Southern Africa. Differences are currently based upon local and regional preferences, training networks, and customs rather than scientific controversy. The pediatric algorithm/decision tree figures presented attempt to follow a common flow of assessments and interventions in coordination with their counterparts for adults.

Survival following pediatric prehospital cardiopulmonary arrest averages only approximately 3% to 17%, and survivors are often neurologically devastated. Most pediatric resuscitation reports have been retrospective in design and plagued with inconsistent resuscitation definitions and patient inclusion criteria. Careful and thoughtful application of uniform guidelines for reporting outcomes of ALS interventions using large, randomized multicenter and multinational clinical trials are clearly needed. Pediatric advisory statements from ILCOR will, by necessity, be a vibrant and evolving guideline fostered by national and international organizations intent on improving the outcome of resuscitation for infants and children worldwide.

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Footnotes

[1] American Heart Association

[2] European Resuscitation Council

[3] American Heart Association and American Academy of Pediatrics

[4] Resuscitation Councils of Southern Africa

[5] Australian Resuscitation Council.

`Pediatric Resuscitation' was approved by the American Heart Association Science Advisory and Coordinating Committee in February 1997.

Appendix 1

Pediatric ILCOR Participants
Robert Bingham, MD (European Resuscitation Council [ERC]); Jon Bland, MD (ERC); David Burchfield, MD (AHA/American Academy of Pediatrics [AAP]); Leon Chameides, MD (AHA); Mary Fran Hazinski, MSN, RN (AHA); John Kattwinkel, MD (AHA/AAP); Efraim Kramer, MD (Resuscitation Councils of Southern Africa); Vinay Nadkarni, MD (AHA); Linda Quan, MD (AHA); F.G. Stoddard, PhD (AHA); James Tiballs, MD (Australian Resuscitation Council); Patrick Van Rempst, MD (ERC); Arno Zaritsky, MD (AHA); David Zideman, MD (ERC); and Jelka Zupan, MD (World Health Organization).

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Figure 1. Comparison of resuscitative interventions for newborns, infants, children, and adults. CPR indicates cardiopulmonary resuscitation; EMS, emergency medical services; BLS, basic life support; and ALS, advanced life support. *Interventions recommended *for suitably trained healthcare providers only.*

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	ILCOR	AHA	HSFC	ERC	RCSA	ARC
Initial shock	2 J/kg	2 J/kg	2 J/kg	2 J/kg	2 J/kg	2 J/kg
Second shock	*2-4 J/kg*	4 J/kg	4 J/kg	2 J/kg	2 J/kg	2-4 J/kg
Third shock	2-4 J/kg	4 J/kg	4 J/kg	4 J/kg	4 J/kg	4 J/kg
First medication	Epinephrine (adrenaline)	Epinephrine 0.01 mg/kg	Epinephrine 0.01 mg/kg	Adrenaline 0.01 mg/kg	Adrenaline 0.01 mg/kg	Adrenaline 0.01 mg/kg
Shocks after first medication	4 J/kg *up to 3 shocks*	4 J/kg × 1 shock	4 J/kg × 1 shock	4 J/kg × 3 shocks	4 J/kg × 3 shocks	4 J/kg × 3 shocks
Second medication	Epinephrine (adrenaline)	Epinephrine and lidocaine	Epinephrine and lidocaine	Adrenaline	Adrenaline and lignocaine	Adrenaline and lignocaine
Shocks after second medication	4 J/kg *up to 3 shocks*	4 J/kg × 1 shock	4 J/kg × 1 shock	4 J/kg × 3 shocks	4 J/kg × 3 shocks	4 J/kg × 3 shocks

Figure 2. Examples of minor differences in recommendations for treatment of ventricular fibrillation and pulseless ventricular tachycardia between the International Liaison Committee on Resuscitation (ILCOR), the American Heart Association (AHA), the Heart and Stroke Foundation of Canada (HSFC), the European Resuscitation Council (ERC), the Resuscitation Councils of Southern Africa (RCSA), and the Australian Resuscitation Council (ARC).

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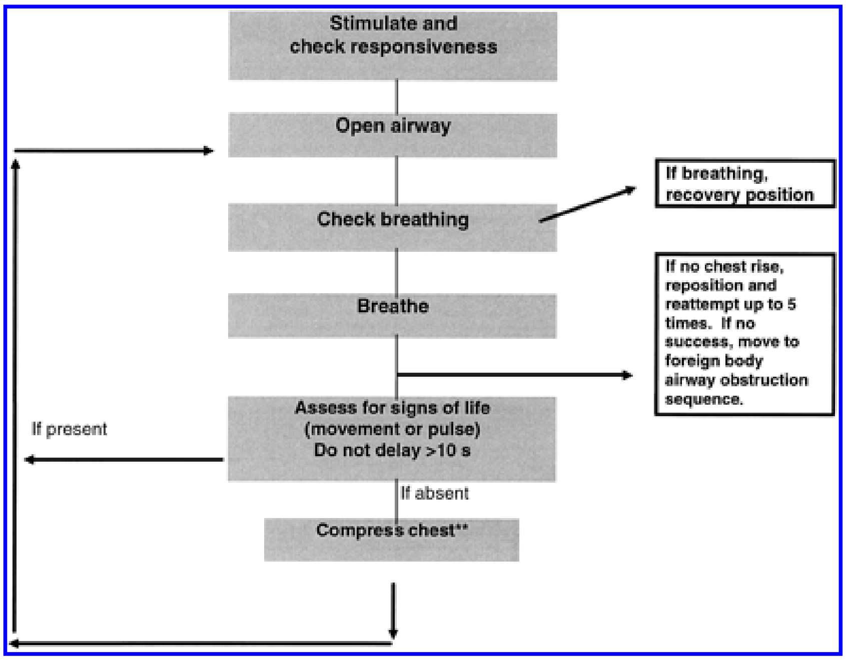

Figure 3. Universal pediatric basic life support (BLS) template for lay rescuers. **Continue rescue breathing and cardiopulmonary resuscitation as indicated. Activate emergency medical services as soon as possible, based on local and regional availability.

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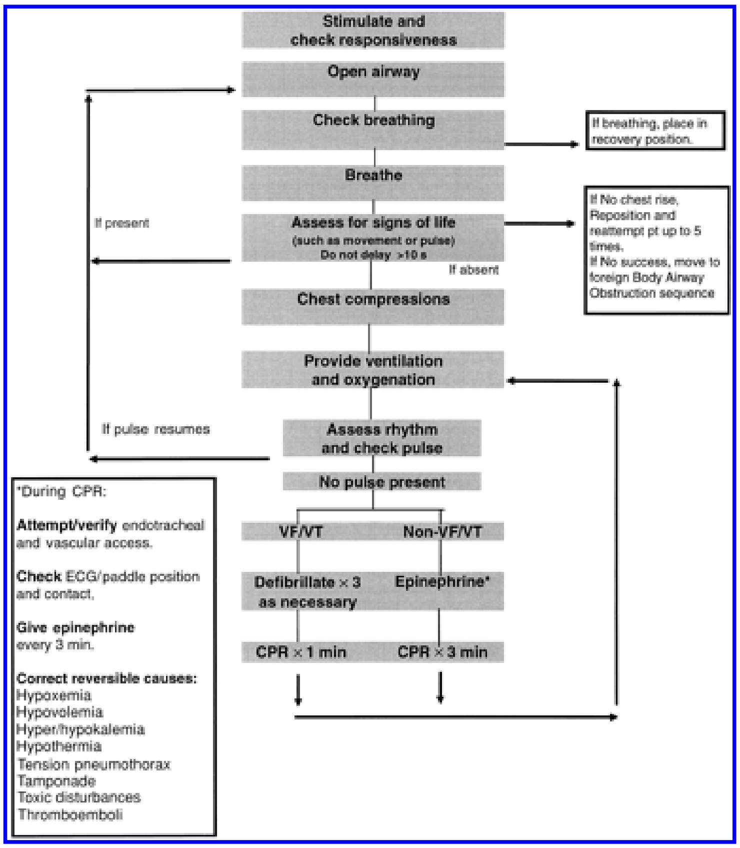

Figure 4. Universal pediatric template for pediatric healthcare providers. VF indicates ventricular fibrillation; VT, ventricular tachycardia; defib, defibrillation; CPR, cardiopulmonary resuscitation; and ECG, electrocardiogram.

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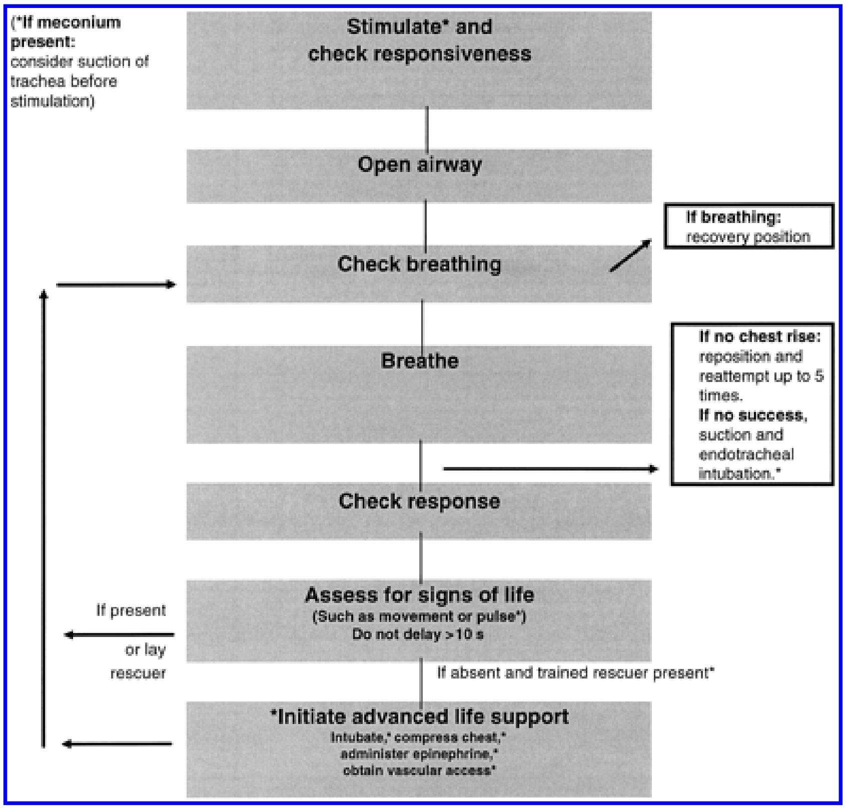

Figure 5. Universal newborn (newly born) template. *Advanced life support interventions recommended *for suitably trained healthcare providers only: pulse check, chest compressions, endotracheal suction and intubation, vascular access, and epinephrine administration.*

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