Paediatric cardiac arrest is not common, the survival rate is poor and any long-term sequelae from hypoxaemia can be devastating. Revised treatment guidelines from the Paediatric Life Support Working Party of European Resuscitation Council have incorporated evidence-based evaluations of the International Liaison Committee on Resuscitation (ILCOR) and have been published in the International Guidelines 2000.

As in previous paediatric guidelines, the emphasis remains upon the treatment of immediate causes of hypoxic cardiac arrest and continuous efficient cardiopulmonary resuscitation. A primary respiratory problem resulting in hypoxia and bradycardia is a common pathway leading to paediatric cardiac arrest. The minority of paediatric cardiac arrests are related to initial cardiac events. The majority of circulatory arrests have a 'non-ventricular fibrillation/non-ventricular tachycardia' rhythm of either asystole or pulseless electrical activity (PEA).

Basic life support manages the initial event using simple techniques for airway control, breathing and the maintenance of a circulation. Advanced life support aims to continue to effectively manage the cardiopulmonary collapse and definitively treat any immediate causes of the arrest. Treatment algorithms have been designed to increase efficiency, team performance and to assist in teaching paediatric resuscitation.

Basic life support in infants and children

The algorithm for basic life support in infants and children is given in Figure 1.

Assessment and treatment

An initial shout for help may alert others and may provide additional assistance. Approach the casualty with care, avoiding any danger, to ensure that the rescuer does not become a second victim. Evaluation of the airway, breathing and circulatory status commences with an assessment of responsiveness. Shout ‘are you alright?’ Any response to the rescuer’s voice or gentle shaking will determine the level of responsiveness of the child. In cases associated with trauma, one hand is placed firmly on the forehead to stabilise the cervical spine before the arm is gently shaken.

Airway opening manoeuvres

Optimal airway opening is achieved by using a head tilt/chin lift manoeuvre and displaces the tongue from the posterior pharyngeal wall. This manoeuvre is performed by placing one hand on the forehead and, with the tips of the fingers of the other hand, gently lifting under the chin. In trauma cases, a head tilt/chin lift manoeuvre may exacerbate any pre-existing cervical spine injury. In this situation, a jaw thrust manoeuvre without head tilt is considered the safest technique for opening the airway.

Visible foreign material in the airway should be carefully removed. Blind finger sweeps are not recommended as they may result in bleeding or worsen the position of an obstructing object in the pharynx.

Breathing

Breathing is assessed by observing the rise and fall of the chest and abdomen, listening over the mouth for breath sounds and feeling for child’s breath on rescuer’s cheek. If breathing is not detected within 10 sec, then rescue breathing by mouth-to-mouth ventilation must be commenced immediately. Infants under the age of 1 year may require the mouth-to-mouth and nose ventilation technique. A seal is made, with the rescuer’s mouth, around the child’s
Basic and advanced life support in children

mouth, or mouth and nose, whilst maintaining the airway patent. The rescuer breathes out into the child and a visible rise of the child’s chest will indicate effective ventilation. Slow breaths, over 1–1.5 sec, at low pressure will lessen the risk of gastric distension. Up to five attempts can be made to achieve two effective ventilations. The availability of a pocket mask or a self-inflating resuscitation bag allows for the addition of supplemental oxygen to the inspired air. Failure of

---

**Fig. 1** The basic life support algorithm.
the child’s chest to rise, despite adjustments in airway opening manoeuvres, increases the suspicion of an inhaled foreign body.

Circulation

Many studies have highlighted the difficulty in accurately performing a pulse check to assess the circulation. The 2000 guidelines recommend that lay rescuers should not perform a pulse check but commence chest compressions if there are no signs of a circulation after two effective rescue breaths. Signs of circulation include breathing, coughing or movement. Healthcare professionals should still assess the circulation by palpating the carotid artery of a child or the brachial artery of an infant. Ten seconds are allowed for assessment of the circulation. Chest compressions are commenced in the absence of signs of circulation, the absence of a pulse or, in infants, if there is a pulse rate of less than 60 beats min⁻¹ together with signs of a poor perfusion.

Cardiac compression techniques

Infants

The two-finger technique is recommended for the sole rescuer. The tips of two fingers are placed on the sternum in the midline, one finger breadth below the inter-nipple line. If two or more suitably trained rescuers are available, then the two thumb, encircling hands technique is now recommended. Here, both hands of one rescuer encircle the infant’s chest, with the thumbs placed anteriorly on the sternum one finger breadth below the inter-nipple line. The second rescuer performs ventilation. This technique has been shown to generate higher peak systolic and coronary perfusion pressure than the two-finger technique. The sternum is depressed by one-third to one-half of the resting chest diameter (1.5–2.5 cm) at a rate of 100 compressions min⁻¹. The ratio of chest compressions to ventilations is 5:1.

Small children (< 8 yr)

Chest compressions are performed using the heel of one hand placed on the sternum one finger breadth above the xiphisternum. The sternum is depressed by one-third to one-half of the resting chest diameter (2.5–3.5 cm) at a rate of 100 compressions min⁻¹. The ratio of chest compressions to ventilations is 5:1.

Larger children (8 yr and above)

Chest compressions are performed using the heels of both hands placed two finger breadths above the xiphisternum. The sternum is depressed by 3.5–5 cm at a rate of 100 compressions min⁻¹. The ratio of chest compressions to ventilations is 15:2.

There has been debate about the synchronisation of chest compressions and ventilations. It is known that intra-aortic pressure and coronary perfusion rises steadily with chest compressions in adults but that this is lost when compressions are stopped to allow for ventilation. In children, it is recommended that ventilation and chest compression be synchronised until after tracheal intubation when they can become asynchronous provided that adequate ventilation is achieved.

Contact the emergency medical services

If no help has arrived after 1 min of resuscitation, then the rescuer should contact the emergency medical services to ensure the arrival of advanced resuscitation drugs, equipment and assistance. If the victim is an infant or small child, then it may be possible to carry them to the telephone and thereby not interrupt resuscitation. An older child may have to be left in order to summon the emergency medical services. On return, if the child has been left, basic life support is resumed whilst awaiting help and then continued without interruption throughout advanced life support, unless there are signs of a return of a circulation.

Advanced life support

On the arrival of advanced life support assistance and equipment, the first priority is to ventilate with high inspired concentration of oxygen. Expired air ventilation delivers approximately 16% inspired oxygen concentration, whereas concentrations up to 90% can be administered using a self-inflating bag-valve-mask system with an oxygen reservoir and an oxygen flow rate of 10–15 litre min⁻¹.

A cardiac monitor/defibrillator should be attached as early as possible to the child and the cardiac rhythm assessed. The rhythm then determines which arm of the treatment ALS algorithm is followed (Fig. 2). Effective basic life support must continue uninterrupted throughout ALS.

The algorithm for advanced paediatric life support is very similar to the equivalent adult protocol. The most obvious difference is the omission of the precordial thump for children. Familiarisation with equipment is essential, as is an understanding of how weight and drug doses changes with age. There are several formulae that estimate body weight from age; although none is ideal, the most commonly used for resuscitation is:

\[
\text{Weight (kg)} = 2 \times (\text{Age} + 4) \quad \text{Eq. 1}
\]

This formula is only useful for children between the ages of 1–10 yr. Areas where resuscitation is frequently performed...
Fig. 2 Paediatric advanced life support algorithm; Resuscitation Council (UK) guidelines.
should display wall charts, such as the Oakley chart, that relate weight to age. Some institutions prefer devices that relate weight to height such as the Broselow tape. Both the chart and the tape have been shown to be better than visual estimations of weight. Furthermore, both provide guidelines for doses of the major resuscitation drugs and sizes of equipment.

Non-ventricular fibrillation or non-ventricular tachycardia (non-VF/VT) – asystole or pulseless electrical activity

This description encompasses the commonest rhythms seen at paediatric cardiopulmonary arrest. Airway compromise or another hypoxic event can result in asystole or a profound bradycardia (< 60 beats min⁻¹). This profound bradycardia, that does not provide adequate cardiac output or tissue perfusion, is treated in the same manner as asystole without waiting for further deterioration in rate.

The first step in the management of non-VF/VT is to administer epinephrine 10 µg kg⁻¹. This may be given by either the intravenous or intra-osseous routes. The former does require that intravenous access has been established and this can be difficult in infants and children. Although central venous access provides rapid access to the central circulation, peripheral venous access is perfectly satisfactory. The intra-osseous route is a particularly useful technique for infants/small children where attempts at venous cannulation have failed. Any drug that can be administered intravenously can be given via the intra-osseous route. If circulatory access cannot be gained quickly, then epinephrine can be given via the tracheal tube. The recommended dose is 10 times the recommended intravenous dose of epinephrine, diluted in up to 5 ml of sterile saline, and delivered via a narrow bore catheter placed beyond the end of the tracheal tube.

Epinephrine should be administered every 3 min throughout the ALS management. Second and subsequent doses of epinephrine should remain at 10 µg kg⁻¹. In sepsis, anaphylaxis and rewarming from hypothermia, where there is associated profound vasodilatation, the dose of intravenous epinephrine should be increased to 100 µg kg⁻¹.

Concurrently with epinephrine administration, the child’s trachea should be intubated with an appropriate sized tracheal tube. Tracheal intubation should be verified by observing equal and bilateral chest wall movement and listening for equal breath sounds in both lung fields. In addition, tracheal tube placement should be confirmed, where possible, by detecting carbon dioxide in the expired air (but this may be complicated by the lack of an adequate pulmonary circulation).

All the reversible causes of cardiac arrest should be considered and treated vigorously if present. These can be easily remembered as the four ‘H’s (hypoxia, hypovolaemia, hyper/hypokalaemia and hypothermia) and the four ‘T’s (toxic/therapeutic disturbances, tension pneumothorax, tamponade and thromboembolism) of resuscitation. Hypovolaemia is a common cause of EMD in children and should be treated promptly with boluses of 20 ml kg⁻¹ of crystalloid or colloid.

Alkalising agents, such as sodium bicarbonate, should be considered where profound acidosis has been measured on blood gas analysis. Excessive sodium bicarbonate can result in hypernatraemia, hyperosmolarity and a metabolic alkalosis with a left shift of the oxyhaemoglobin dissociation curve resulting in impaired oxygen delivery.

If a sample of blood or marrow is obtained, then an estimate of the blood glucose concentration can be made. Low blood glucose (< 3 mmol litre⁻¹) should be treated with 5 ml kg⁻¹ of 10% dextrose solution and the glucose concentration re-assessed.

Ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT)

These rhythms are not common in children, with a reported incidence of 7–15%. However, they may occur in association with hypothermia, tricyclic antidepressant poisoning and intrinsic cardiac disease. Delays in defibrillation will worsen resuscitation outcome. When VF or pulseless VT is diagnosed, the defibrillator paddles (with gel pads) or adhesive defibrillation pads are sited. One paddle is positioned over the apex of the heart just anterior to the mid axillary line; the other is placed immediately below the clavicle just to the right of the sternum. If only adult paddles are available for a child below 10 kg body weight, then one is sited on the left lower part of the chest anteriorly and the other directly behind this on the child’s back. Paediatric paddles or pads (4.5 cm) can be used for children < 10 kg body weight. The recommended sequence for child defibrillation is 2 J kg⁻¹, 2 J kg⁻¹ and 4 J kg⁻¹. Many defibrillators have preset energy levels; the nearest energy value to that calculated should be used. The monitor is observed after each defibrillation attempt and, if the rhythm changes, then a pulse check for 10 sec should be performed. If the rhythm does not change after the three defibrillation attempts, then basic life support is resumed for 1 min. After 1 min of CPR, the next sequence of three defibrillation attempts, all at 4 J kg⁻¹ are delivered. The child’s trachea should be intubated and vascular access achieved. The algorithm continues as
described above for non-VF/VT but with attempts at defibrillation every 1 min.

Amiodarone is now recommended for the treatment of shock resistant VF or pulseless VT. Amiodarone is given as an intravenous bolus in an initial dose of 5 mg kg$^{-1}$ and can be repeated to a maximum of 15 mg kg$^{-1}$ day$^{-1}$. Amiodarone can cause hypotension and bradycardia and its use in resuscitation in children is still under evaluation.

Lidocaine 1 mg kg$^{-1}$ has also been recommended for use in shock resistant VF and VT.

**Automatic external defibrillators (AEDs) and biphasic defibrillators**

Automatic external defibrillators (AEDs) are being used commonly in adults to assess and treat ventricular fibrillation. However, the ability of AEDs to accurately diagnose ventricular fibrillation in children is still under investigation. In addition, the energy delivered by AEDs is at preset fixed levels suitable for adults and, as such, may be too high for small children. It is recommended that adult AEDs should only be used on children aged 8 yr or above (> 25 kg body weight) when no other defibrillator is immediately available. Some AEDs now have paediatric pads that have been fitted with an attenuator to limit the energy delivered to 50 J. The new technology biphasic defibrillators have been shown to have an equivalent or higher efficacy for terminating VF at lower energy levels in adults. There are, unfortunately, little data to guide the use of biphasic defibrillators in children.

**Audit**

It is essential that all paediatric resuscitation events are fully documented and carefully audited. It is only through the process of audit that the assessment of the efficacy of the recommended protocols can be made and changes leading to improved outcomes introduced.

**Key references**


See multiple choice questions 78–81.