

life without an explicit request, and therefore the possibility of addressing this issue and diminishing this category by securing patients' wishes before they become incompetent (for example, by the use of living wills).

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Guidelines for paediatric life support

Paediatric Life Support Working Party of the European Resuscitation Council

The paediatric life support working party of the European Resuscitation Council was set up in 1992 with the aim of producing guidelines for basic and advanced paediatric resuscitation that would be acceptable throughout Europe. The commonest cause of cardiac arrest in children is problems with the airway. The resulting difficulties in breathing and the associated hypoxia rapidly cause a severe bradycardia or asystole. In contrast, adults have primary cardiac events resulting in ventricular fibrillation. This important difference in the pathogenesis of paediatric and adult cardiac arrest is reflected in these European Resuscitation Council guidelines, which complement those already published for adults.

Reported outcomes of cardiopulmonary resuscitation in infancy and childhood are variable.¹⁻¹⁶ Some of the variability arises from the poor distinction in many reports between a respiratory arrest, which more often has a good outcome,^{3,5,6} and a cardiac arrest, which has a much worse outcome.^{2,3,7,8} A poorer outcome is also seen when arrests occur outside hospital rather than in hospital.^{4,5,14} Overall, the outcome from cardiac arrest is worse in children than in adults¹⁵ because of the differences in the pathogenesis of cardiac arrest. In adults the commonest cause of cardiac arrest is heart disease but other causes predominate in children.

The commonest underlying cause of cardiac arrest in children is respiratory failure. This may result from lung or airway disease such as croup, bronchiolitis, asthma, or pneumonia, or from injury such as birth asphyxia, inhalation of a foreign body, or pneumothorax. Respiratory depression caused by prolonged convulsions, raised intracranial pressure, neuromuscular problems, or poisoning can also lead to cardiac arrest. The second commonest cause of cardiac

arrest is circulatory failure, usually due to loss of fluid or blood or to sepsis. Cardiac arrests of primarily cardiac origin, for example arrhythmias and pump failure, are uncommon in childhood and are seen most often in children in the intensive care ward of a paediatric cardiothoracic unit.

The poor long term outcome from many cardiac arrests in childhood is related to the severity of cellular anoxia that has to occur before the child's previously healthy heart succumbs. Organs sensitive to anoxia such as the brain and kidney may be massively damaged before the heart itself stops. In such cases cardiopulmonary resuscitation may restore cardiac output but the child dies from multisystem failure in the ensuing days or survives with serious neurological damage. Prevention of injury and earlier recognition of illness is clearly a more effective approach in these children. On a more positive note, there is a recent report of a higher incidence of neurologically intact survival after cardiac arrest.¹³

Different underlying causes of cardiac arrest exist at different ages. Asphyxia is the commonest cause of cardiac arrest at birth. In infancy, respiratory illness is the commonest cause, followed by sepsis, and in later childhood trauma becomes the commonest cause of cardiac arrest. We do not yet understand the mechanism of death in the sudden infant death syndrome, but current theories include an abnormal heat control mechanism. This has led to the recommendation in the United Kingdom that infants are nursed in the supine position.

In 1992 the European Resuscitation Council published its recommendations for adult basic life support and adult advanced life support.^{17,18} The present paper details the recommendations of the working party on paediatric resuscitation of the European Resuscitation Council. The first part of the paper gives the recom-

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Members of the working party are listed at the end of this report

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recommendations for basic life support and the immediate management of choking infants or children. The second part describes the advanced management of pulseless arrhythmias in infancy and childhood.

Paediatric basic life support

Early diagnosis and aggressive treatment of respiratory or cardiac insufficiency aimed at avoiding cardiac arrest is the key to improving survival without neurological deficit in seriously ill patients and children. Establishing a clear airway and oxygenation are the most important actions in paediatric resuscitation. These actions are prerequisite to other forms of treatment.

Definitions

Infant: Aged under 1 year

Child: From the end of the first year to adulthood

Basic life support refers to the maintenance of the airway and support of respiration and circulation without using equipment (fig 1). The following guidelines have been agreed as a basis for paediatric cardiopulmonary resuscitation by one person.

Resuscitation should begin immediately without waiting for the arrival of equipment. This is essential in infants and children because clearing the airway may be all that is required. Assessment and treatment should proceed simultaneously to avoid losing vital time. As in any resuscitation, the airway, breathing, circulation sequence is the most appropriate.

If aspiration of a foreign body is strongly suspected because of sudden onset of severe obstruction of the upper airway, the steps outlined in the section on choking should be taken immediately.

ASSESS RESPONSIVENESS

Determine responsiveness by speaking loudly, shaking, or pinching gently. If the child is unresponsive shout for help. Move the child only if he or she is in a dangerous location. If there is evidence of trauma a neck injury may be present, and the child should be

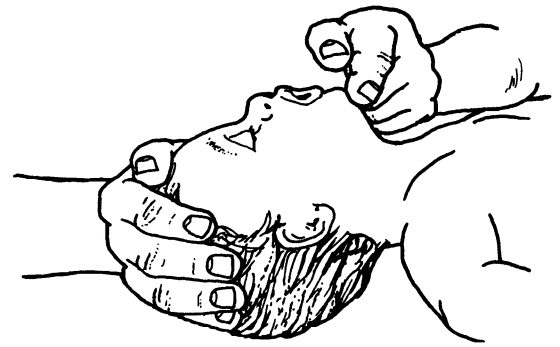


FIG 2—Opening the infant airway with head tilt and chin lift manoeuvre

moved with the cervical spine completely immobilised, avoiding flexion, extension, or rotation of the head.

OPEN AIRWAY

Unconscious infants or children need active airway support to maintain patency of the airway. Visible foreign bodies in the mouth that can be easily grasped should be removed, but do not use blind finger sweeps of the posterior pharynx as they can impact any obstruction further down the airway. The airway should be opened by one of the two following manoeuvres.

Head tilt and chin lift—Place one hand on the forehead and tilt the head back into a neutral or slightly extended position (fig 2). Avoid excessive neck extension. Lift the lower jaw with the tip of one finger of the other hand. Take care not to press on the soft tissues under the chin.

Jaw thrust—This is an alternative to the head tilt and chin lift manoeuvre. It should be used if cervical spine injury is suspected as it does not extend the neck. Place the index fingers of both hands behind the angles of the lower jaw and lift upwards, carrying the lower jaw and tongue away from the posterior pharynx. At the same time try to keep the mouth open by depressing the tip of the chin with the thumbs.

CHECK BREATHING

Assess respiration by

- Looking for chest and abdominal movement
- Listening at the mouth and nose for breath sounds
- Feeling for expired air movement with your cheek.

If the child's chest and abdomen are moving but no air can be heard or felt the airway is obstructed. Readjust the airway (jaw thrust is usually the most effective) and consider obstruction by a foreign body (see choking protocol).

BREATHE (EXPIRED AIR RESPIRATION)

If no spontaneous respiration is detected start expired air respiration immediately. Maintain a clear airway with the head tilt and chin lift or jaw thrust manoeuvres and breathe into the patient's mouth and nose (for infants) or mouth only (for older children). Five breaths should be delivered, each lasting about 1 to 1.5 seconds. Take a breath between each inflation to optimise the inspired gas mixture. Observe the child's chest movement carefully during inflations. He or she should appear to take a deep breath. If the chest does not rise or the movement is inadequate, readjust the airway position and consider obstruction with a foreign body. Minimise gastric distension by optimising the alignment of the airway and giving slow and steady inflations.

CHECK PULSE

Check for the presence, rate, and volume of the pulse. The brachial pulse is easiest to feel in infants.¹⁹ It is located on the inside of the middle of the upper arm

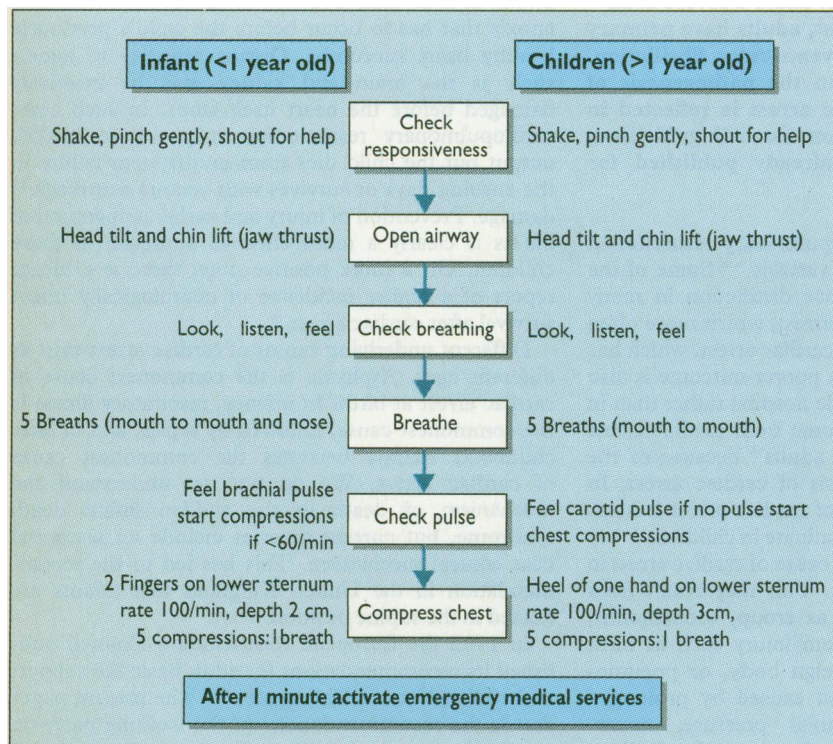


FIG 1—Paediatric basic life support

and can be felt by hooking a finger over the abducted and externally rotated upper arm (fig 3). The femoral pulse is an alternative. In older children the carotid pulse should be palpated. If the pulse rate is less than 60/min in infants or absent in older children, start external chest compressions without further delay.

COMPRESS CHEST (EXTERNAL CHEST COMPRESSIONS)

In infants and children the heart lies under the lower third of the sternum.^{20 21} In infants the sternum is compressed with two fingers of one hand, the upper finger being one finger's breadth below an imaginary line joining the nipples (fig 4). The sternum is compressed about 2 cm. An alternative technique in newborns and small infants is to use the thumbs at the point described above with the fingers of both hands

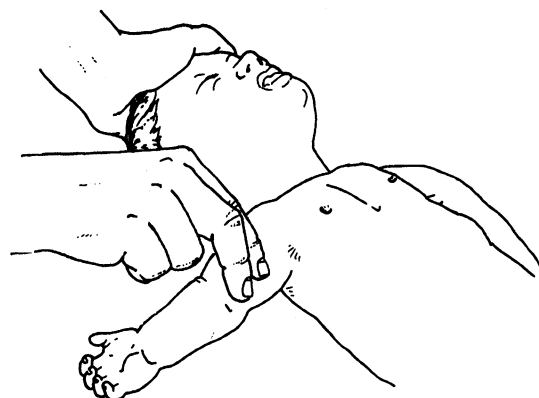


FIG 3—Position of brachial pulse in infants

overlapping behind the infant's back.^{22 23} If this second method is used you must ensure that the chest is allowed to fully re-expand between compressions.

In children the heel of one hand is used at a compression point two fingers' breadth above the xiphoid process. The depth of compression is about 3 cm.

In both infants and children the rate should be 100/min and the ratio of compressions to ventilations should be 5:1 irrespective of the number of rescuers. The compression phase should occupy half of the cycle and should be smooth not jerky.

In larger older children in whom the heel of one hand is found to give an insufficient compression force, the adult two handed method of chest compression can be used.¹⁷ The compression depth should be 4-5 cm, at a rate of about 80/min with a compression to ventilation ratio of 15:2.

ACTIVATION OF EMERGENCY MEDICAL SERVICES

After one minute of basic life support the emergency medical services must be activated. You should tell the service the rough age of the child. You may be able to carry infants or small children to the telephone, but older children may have to be left. Basic life support must be restarted as soon as possible after telephoning and continued with no further interruptions until help arrives.

If the child is breathing spontaneously his or her efforts to clear the obstruction should be encouraged. Intervention is necessary only if these attempts are clearly ineffective and respiration is inadequate.

Choking

If upper airway obstruction due to aspiration of a foreign body is witnessed or strongly suspected, special measures to clear the airway must be undertaken (fig 5).²⁴ Never perform blind finger sweeps of the pharynx as these can impact a foreign body in the larynx. Use measures intended to create a sharp increase in pressure within the chest cavity—an artificial cough.

BACK BLOWS

Hold the infant or child in a prone position and deliver five smart blows to the middle of the back between the shoulder blades. The head must be lower than the chest during this manoeuvre. This can be achieved by holding a small infant along the forearm or, for older children, across the thighs while kneeling.

CHEST THRUSTS

With the child in a supine position and with the head lower than the chest, give five thrusts to the sternum. The technique of chest thrusts is similar to that for chest compressions. The chest thrusts should be sharper and more vigorous than compressions and carried out at a slower rate—about 20 per minute.

CHECK MOUTH

After five back blows and five chest thrusts check the mouth and remove any visible foreign bodies.

OPEN AIRWAY

Reposition the head by the head tilt and chin lift or jaw thrust manoeuvre and reassess the air entry.

BREATHE

If there are no signs of effective spontaneous respiration or if the airway remains obstructed attempt rescue breathing. It may be possible to ventilate the

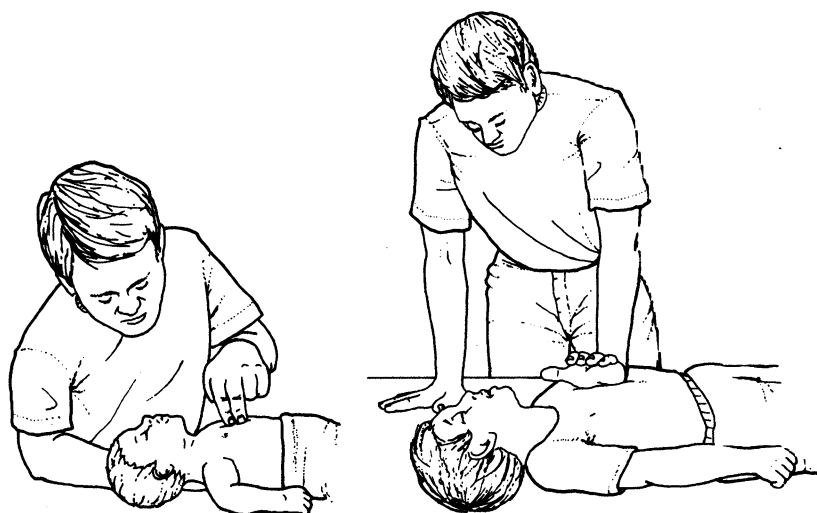


FIG 4—Chest compression in infants and children

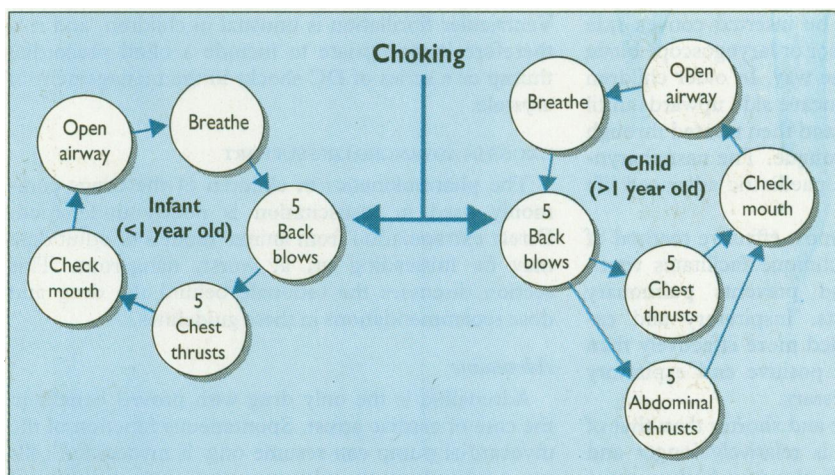


FIG 5—Management of choking in infants and children

child by positive pressure expired air ventilation when the airway is partially obstructed but care must be taken to ensure that the child exhales most of this artificial ventilation after each breath.

REPEAT

If the above procedure is unsuccessful in infants it should be repeated until the airway is cleared and effective respiration established. In children abdominal thrusts are substituted for chest thrusts after the second round of back blows. Subsequently back blows are combined with chest thrusts or abdominal thrusts in alternate cycles until the airway is cleared.

ABDOMINAL THRUSTS

In children over 1 year deliver five abdominal thrusts after the second five back blows. Use the upright position (Heimlich manoeuvre) if the child is conscious. Unconscious children should be laid supine and the heel of one hand placed in the middle of the upper abdomen. Five sharp thrusts should be directed upwards towards the diaphragm. Abdominal thrusts are not recommended in infants because they may rupture the abdominal viscera.

This choking protocol must be continued until the foreign body is cleared.

Paediatric advanced life support

Advanced life support of pulseless children aims at perfusing the coronary and cerebral arteries with oxygenated blood to maintain oxygenation of the brain and to enable the heart to regain its effectiveness as a pump. Effective basic life support is a prerequisite for successful advanced life support.

AIRWAY AND VENTILATION MANAGEMENT

A secure airway and effective ventilation are essential. They are a priority in the management of asystole and electromechanical dissociation. Airway and ventilation management are particularly important in infants and children in cardiac arrest because respiratory problems are often the cause of the arrest.

Oxygen in as high a concentration as possible should be used from the onset in all patients undergoing advanced life support. It should be humidified wherever possible.

Airway adjuncts

Use an oropharyngeal (Guedel) airway if the child's airway cannot be maintained adequately during bag and mask ventilation. If prolonged ventilation is required, however, intubation is the best method of securing the airway. A correctly sized airway should extend from the centre of the mouth to the angle of the jaw when laid against the child's face. In small children or infants the airway should be inserted convex side upwards; use a tongue depressor or laryngoscope blade to guide the tongue out of the way. In older children the airway can be inserted concave side upwards until the tip reaches the soft palate and then rotated through 180° and slid back over the tongue. The nasopharyngeal airway has little place in paediatric advanced life support.

Tracheal intubation is the most effective method of securing the airway. The technique facilitates ventilation and oxygenation and prevents pulmonary aspiration of gastric contents. Inspiratory and expiratory times can be controlled more effectively than with a bag and mask and a positive end expiratory pressure can be applied if necessary.

A child's larynx is narrower and shorter than that of an adult, and the epiglottis is relatively longer and more U shaped. The larynx is also in a higher, more anterior, and more acutely angled position than in the

adult. As children grow, their upper airway structures descend. This occurs rapidly in the first two years of life. After this there is little change until puberty when there is a further descent of the epiglottis and cricoid.²⁵ A straight bladed laryngoscope is therefore easier to use in infants and young children, with a more curved blade for older children. Plain plastic tracheal tubes are most useful in children as they cause less local oedema. Uncuffed tubes are preferred until puberty to minimise damage to the cricoid ring, which is narrower in children than in adults.

In children aged over 1 year the appropriate size of an tracheal tube can be assessed by the following formula: internal diameter (mm) = (age in years/4) + 4.

Another useful guideline is to use a tube of about the same diameter as the child's little finger or of a size that will just fit into the nostril. Full term newborn infants usually require a tube of size 3 to 3.5 increasing to a size 4 by 6-9 months of age.

Basic life support must not be interrupted for more than 30 seconds. After this interval the child must be reoxygenated before a further attempt at intubation is made.

Oxygenation and ventilation adjuncts

A flow meter capable of delivering 15 litres per minute should be attached to the oxygen supply from either a central wall pipeline supply or an independent oxygen cylinder. Face masks for mouth to mask or bag valve mask ventilation should be made of soft clear plastic, have a low dead space, and conform to the child's face to give a good seal. The face mask should be attached to a self inflating bag of either 500 ml or 1600 ml. The smaller size has a pressure limiting valve. Occasionally, this may need to be overridden if the child's lungs have a very poor compliance. The bag valve mask system must be used with a reservoir attachment. This enables an oxygen concentration of over 90% to be delivered. The T piece and open ended bag system is not recommended for less experienced operators as it requires specialist training. It does, however, allow the operator to gain a better impression of lung compliance.

ASYSTOLE

Asystole is the most common arrest rhythm in infancy and childhood. It is the final common pathway of respiratory or circulatory failure. It is usually preceded by an agonal bradycardia. The diagnosis of asystole is made on electrocardiographic evidence in a pulseless patient. Care must be taken to ensure that the electrocardiograph leads are correctly positioned and attached and that the monitor gain is turned up.

Figure 6 shows the protocol for managing asystole. Effective basic life support and ventilation with high flow oxygen through a patent airway are a prerequisite. Ventricular fibrillation is unusual in children, and it is therefore inappropriate to include a blind precordial thump or a series of DC shocks in the management of asystole.

DRUGS IN ADVANCED LIFE SUPPORT

The pharmacokinetics in children of the drugs commonly used in resuscitation is poorly understood. Direct extrapolation from animal models or adult data may be misleading or, at worst, dangerous. This section discusses the rationale behind the drug and dose recommendations in these guidelines.

Adrenaline

Adrenaline is the only drug with proved benefit in the case of cardiac arrest. Spontaneous function of the myocardial pump can resume only if myocardial cells are perfused at an adequate rate with oxygenated blood. In animal experiments this perfusion pressure is

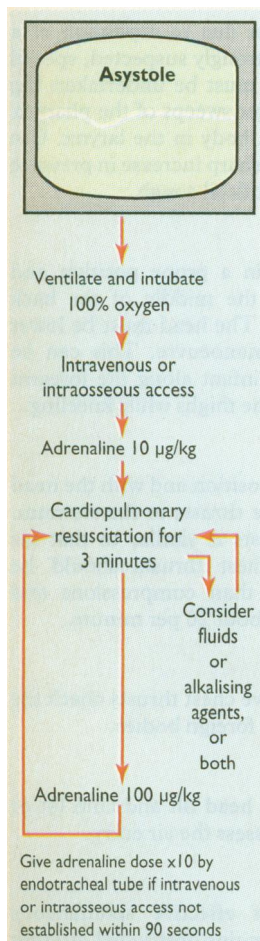


FIG 6—Management of asystole

at least 1.3 to 2.6 kPa.^{26, 27} Adrenaline increases peripheral vascular resistance and thus aortic "diastolic" pressure, which is the driving force for coronary perfusion in cardiac arrest.²⁸ Animal studies show that it is the stimulation of the α adrenergic receptor that is important in determining outcome in cardiac arrest.²⁹

The initial dose of adrenaline recommended in paediatric cardiac arrest remains 10 μ g/kg. However, recent animal studies show improved coronary and cerebral perfusion in arrested animals treated with higher doses of adrenaline.³⁰⁻³² A hypothesis has been advanced from animal studies that the catecholamine dose for improvement of myocardial perfusion during cardiopulmonary resuscitation is mainly influenced by the duration of cardiac arrest and hence the degree of hypoxia, metabolic acidosis, and hypercapnia in the tissues.³³ In the only paediatric clinical trial children with cardiac arrest in asystole treated with large adrenaline doses showed improved neurological outcome.³⁴ But three unpublished large prospective blinded trials in adults found no difference in survival between standard and high dose regimens of adrenergic agonists.³⁵ The discrepancy between these data, animal experiments, and the small uncontrolled series of paediatric cardiac arrests may be explained by the hypothesis that high dose adrenaline increases myocardial oxygen delivery only in people without atherosclerosis. In addition, concern about using high adrenaline doses in children is raised by studies showing coronary vasoconstriction in infant pigs³⁶ and arterial hypertension after successful resuscitation.³⁷ Therefore, the protocol retains the lower dose of 10 μ g/kg for the first adrenaline doses, but for second and subsequent doses a 10-fold increase is recommended. The situation in an asystolic child who does not respond to the first dose of adrenaline is desperate³⁸ and warrants heroic action. A detailed review of the use of adrenaline in cardiopulmonary resuscitation concluded that animal studies, human physiological models, and case reports tend to favour the use of high dose adrenaline but randomised clinical trials are needed to assess the effects.³⁹

Atropine

Atropine has not been shown to be necessary in paediatric resuscitation. It can be used to treat bradycardia. In infancy and childhood, however, hypoxia is the most important cause of bradycardia, so adequate ventilation and oxygenation should be achieved before atropine is considered. Atropine is used to block vagal tone that might depress myocardial electrical response, but it should not be used in place of measures of known efficacy. It should be considered where there is evidence that increased vagal tone has been influential in causing cardiac arrest—for example, during airway manipulation. The minimum dose of atropine to avoid a paradoxical parasympathetic action is 0.1 mg. The initial dose is 0.02 mg/kg and the maximum dose is 1 mg in children and 2 mg in adolescents.

Bicarbonate

Alkalisating agents, usually bicarbonate, have been routinely used in resuscitation of children for many years.¹ The rationale has been an assumption that cardiac arrest leads to acidosis and that reversing the acidosis is beneficial. The first unknown factor is the degree of acidosis, especially in children who may have had a prolonged period of respiratory or circulatory insufficiency before cardiac arrest. In arrested patients the arterial pH does not reflect tissue pH. This is better assessed by measuring mixed venous pH.⁴⁰⁻⁴² Cellular acidosis has detrimental effects on the contractility of the myocardium,⁴³ the peripheral vasculature,⁴⁴ and on the response to adrenaline.⁴⁵ However, some acidosis

can help promote cellular oxygenation by shifting the oxygen dissociation curve and by increasing the level of endogenous catecholamines.⁴⁶⁻⁴⁹

Infusion of sodium bicarbonate by central or peripheral routes significantly increased right atrial pH in puppies in experimental cardiac arrest.⁵⁰ However, increasing the pH of blood in the coronary vein by either carbon dioxide consuming (carbicarb) or carbon dioxide generating buffers (bicarbonate) had no effect on outcome in experimental animals with ventricular fibrillation.⁵¹ Indeed, there was evidence that the hyperosmolar solution increased right atrial pressure and therefore could decrease myocardial perfusion pressure.^{51, 52} A particular concern with bicarbonate is that it generates carbon dioxide in its buffering action. The carbon dioxide rapidly diffuses into cells, further lowering intracellular pH. Other alkalisating agents such as trometamol and carbicarb (an equimolar combination of sodium bicarbonate and sodium carbonate) do not generate carbon dioxide. However, there are no clinical studies available of their efficacy in children in cardiac arrest. In pigs both trometamol and bicarbonate were shown to have no beneficial effect on resuscitability. In addition, treatment with trometamol produced an unexpected vasodilator effect which reduced mean aortic and coronary perfusion pressures to levels that are known to reduce survival.⁵³

Our recommendations are therefore that alkalisating agents are of unproved benefit and should be used after clinical consideration of profound acidosis in patients with respiratory or circulatory arrest if the first dose of adrenaline has been ineffective. The dose of bicarbonate is 1 mmol/kg given as a single bolus slow intravenous injection before the second dose of adrenaline. If an alkalisating agent is used the cannula must be flushed with normal saline before subsequent infusion of a catecholamine as catecholamines are inactivated by the alkalisating agent. Subsequent treatment with alkalisating agents should be guided by the blood pH. Effective chest compressions and ventilation are more effective at raising myocardial pH in cardiac arrest.

Calcium

Calcium has been implicated in reperfusion injury of ischaemic organs⁵⁴ and has not been shown to be of use in refractory asystole or electromechanical dissociation.^{55, 56} It is therefore no longer recommended in cardiac arrest unless the patient has proved hypocalcaemia, hypermagnesaemia, and hyperkalaemia. If calcium therapy is indicated the chloride salt is more effective than the gluconate salt.⁵⁷ The dose of calcium chloride is 10-30 mg/kg intravenously.

Fluid therapy

A bolus of normal saline should follow the intravenous or intraosseous injection of any drug used in resuscitation, especially if the injection is peripheral. The amount should be 5-20 ml depending on the size of the child. When cardiac arrest has resulted from circulatory failure, a larger bolus of fluid should be given if there is no response or a poor response to the initial dose of adrenaline. Examples of such cases are children with hypovolaemia from blood loss, gastroenteritis, etc, or with sepsis where a profound distributive hypovolaemic shock may occur.⁵⁸ These children require 20 ml/kg of a crystalloid, such as normal saline or Ringer's lactate, or a colloid, such as 5% human albumin or an artificial colloid. Take care not to overload the venous circulation because an increase in right atrial pressure will decrease coronary perfusion pressure.

Glucose

Sick children and especially infants may be hypoglycaemic. Look for evidence during resuscitation and

treat proved hypoglycaemia with 0.5 g/kg of glucose given as a 10% or 25% solution slowly. Indiscriminate or excessive treatment with glucose should be avoided because animal evidence suggests that hyperglycaemia increases ischaemic brain injury.⁵⁹ An infusion of 5% dextrose at 15 ml/kg/h given before and after an arrest was associated with a significantly worse neurological outcome in experimental kittens.⁶⁰

VENTRICULAR FIBRILLATION

Ventricular fibrillation is unusual in children but it is occasionally seen in the cardiothoracic intensive care unit or in patients being investigated for congenital heart disease. In other patients there is usually an underlying cause that may need correction before defibrillation is successful—for example, hypothermia, arrhythmia inducing drugs such as tricyclic antidepressants, and electrolyte abnormalities such as hyperkalaemia.

Figure 7 shows the protocol for treating ventricular fibrillation and pulseless ventricular tachycardia. In contrast to the treatment of asystole, defibrillation takes precedence. A precordial thump can be given and may be effective if the start of ventricular fibrillation was witnessed. The energy dose is 2 J/kg rising to 4 J/kg if two shocks of the lower dose are ineffectual. This recommendation is based on effective defibrillation attempts in children with ventricular fibrillation.^{61 62} For defibrillators with stepped current levels the nearest higher step to the current required should be selected. Ventilation and chest compressions should be continued at all times except when shocks are being delivered or the electrocardiogram being studied for evidence of change. The first three shocks and subsequent groups of three shocks should be delivered in quick succession. The first shock lowers impedance and therefore increases the energy to the heart from the next shock. Paediatric paddles should be used in children below 10 kg, but in bigger children the larger adult electrode will minimise transthoracic impedance and should be used when the child's thorax is broad enough to permit electrode to chest contact over the entire paddle surface.⁶³ One paddle should be placed over the apex of the heart and one beneath the right clavicle.

If three shocks are not effective priority must be given to supporting coronary and cerebral perfusion as described for asystole. The airway should be secured and the patient ventilated with oxygen at a high flow rate. Intravenous or intraosseous access should be obtained and adrenaline given together with the continuation of ventilation and chest compressions before the next sequence of shocks. At this stage, attempts at identifying and relieving any underlying condition such as hypothermia or electrolyte imbalance should be progressing. If there is no response after three sets of three sequential shocks at 4 J/kg with chest compression, ventilation, oxygenation, and adrenaline support, different paddle positions can be tried—for example, front to back—and antiarrhythmic and alkalisating drugs should be considered. The same caveats apply to the use of alkalisating agents in ventricular fibrillation as in asystole.

The use of antiarrhythmics such as lignocaine is now in question. Lignocaine has been shown to prevent ventricular fibrillation but not to reverse it.⁶⁴ The dose of lignocaine in children is 1 mg/kg. There is little experience with bretylium in children. Phenytoin has a specific place in the management of ventricular tachycardia induced by tricyclic antiarrhythmics. Continuing efforts should be directed to relieving any underlying factor.

ELECTROMECHANICAL DISSOCIATION

As in ventricular fibrillation there may be an

underlying remediable cause for electromechanical dissociation (pulseless electrical activity) in children. This cause should be sought while life support continues. The most likely cause for apparent electromechanical dissociation is profound hypovolaemic shock causing impalpable central pulses while there is still electrical activity in the heart. If not treated this rhythm will soon degenerate through agonal bradycardia to asystole. Other underlying causes to consider, especially in trauma, are tension pneumothorax and cardiac tamponade. Although a pulmonary embolism can cause electromechanical dissociation, it is extremely rare in childhood. Metabolic abnormalities such as hypothermia, electrolyte imbalance, and a drug overdose should also be considered. Occasionally air trapping in a ventilated baby with bronchiolitis may be so severe that it causes obstruction to cardiac output and apparent electromechanical dissociation.

Figure 8 shows the protocol for treating electromechanical dissociation. The process is similar to that for asystole, with oxygenation and ventilation accompanying basic life support and adrenaline to support coronary and cerebral perfusion. In view of the likelihood of correctable hypovolaemia, early use of a bolus of 20 ml/kg of crystalloid or colloid is indicated. If fluid replacement is initially unsuccessful cerebral and coronary perfusion should be sustained by ventilation, chest compressions, and adrenaline 100 µg/kg every three minutes while trying to identify and correct any of the underlying causes suggested.

Routes of drug and fluid administration

Venous—Speed is vital when giving drugs and fluid to patients in cardiac arrest. Peripheral venous access in small ill children is notoriously difficult. Central venous access is hazardous in small children and unlikely to provide a more rapid onset of action of drugs than peripheral access.⁵⁰ If venous access is already available it should be used. Otherwise peripheral venous access should be attempted. If access is not gained within 90 seconds bone marrow (intraosseous) access should be attempted.

Intraosseous—Intraosseous access is a safe, simple, rapid means of access for children of all ages and even adults. Resuscitation drugs, fluid, and blood can be safely given through this route and rapidly reach the heart.⁶⁵⁻⁶⁸ Complications are uncommon and usually relate to prolonged use (which is not recommended) or poor technique.^{69 70} Marrow aspirate can be drawn and used to estimate concentrations of haemoglobin, sodium, potassium, chloride, and glucose⁷¹; venous pH; and blood groups.

Endotracheal—If circulatory access is impossible to attain within two to three minutes, some drugs, including adrenaline, atropine, and lignocaine, can be given down the tracheal tube. Animal and human data suggest that the endotracheal dose of adrenaline should be 10 times the standard dose,^{72 73} but doubts have been cast on the reliability of this route and intravenous or intraosseous access is preferable. Although both lignocaine and atropine can also be given through the endotracheal route, there is no information on the recommended dose. If the endotracheal route is used the drug should be injected deep into the bronchial tree by using a fine cannula through the tracheal tube and flushed in with an equal volume of normal saline. Several rapid ventilations should then follow.

Drug doses and equipment sizes—An important problem is the correct estimation of drug and fluid doses and equipment sizes. There are two systems in current use. The first uses a length based calculation and a specifically designed tape measure.⁷⁴ The other uses a length-weight-age nomogram chart.^{75 76} It is important to become familiar with one system.

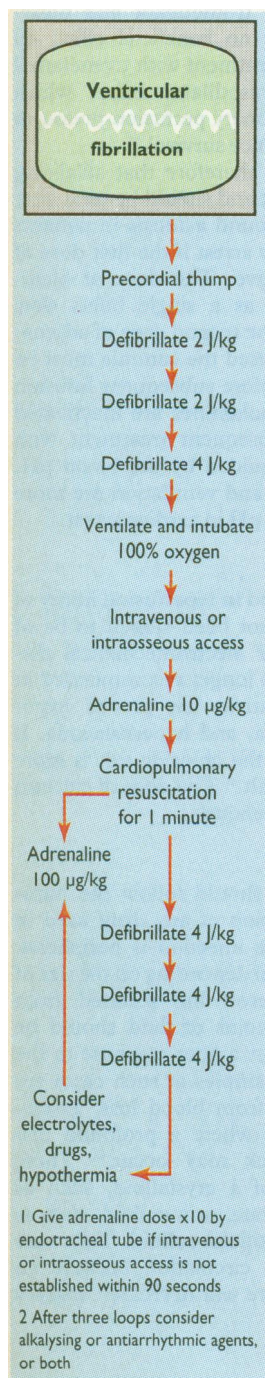


FIG 7—Management of ventricular fibrillation

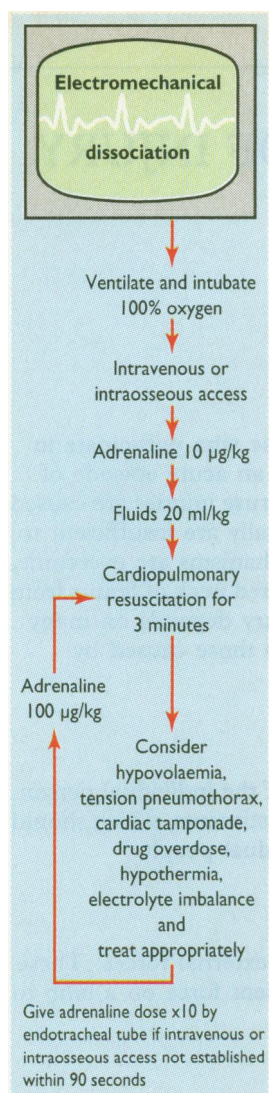


FIG 8—Management of electromechanical dissociation

Training courses

To gain the necessary skills for the effective management of cardiac arrest in infancy and childhood the working party recommends that doctors and nurses attend a course such as the paediatric advanced life support course or the advanced paediatric life support (UK) course. Both are currently held at several centres throughout Europe.

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