ANZCOR Guideline 12.1 – Introduction to Paediatric Advanced Life Support

Summary

Who does this guideline apply to?

This guideline applies to infants and children.

Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

Recommendations

The Australian and New Zealand Resuscitation Committee on Resuscitation (ANZCOR) make the following recommendations:

1. Use the term “infant” to refer to 0-1 yr of age and “child” to refer to 1-8yrs of age.
2. Suggest the use of paediatric medical emergency team (MET) or rapid response team (RRT) systems in all hospitals that care for children.
3. Suggest that adult resuscitation protocols may be used for older children aged 9 years and above (bearing in mind that this age group have lower rates of ventricular fibrillation or pulseless ventricular tachycardia than adults).
1 Introduction

These Guidelines are provided by the Australian and New Zealand Resuscitation Councils (ARC, NZRC) to assist in the resuscitation of infants and children. They are intended to act as adjuncts to Advanced Life Support guidelines for adults published by the ARC and NZRC in guidelines 11.1 – 11.1. Differences from the adult guidelines reflect differences in the causes of cardiorespiratory arrest and differences in anatomy and physiology between infants, children and adults. Differences from basic life support for ratios of chest compression and lung inflation reflect the use of equipment in advanced life support, an expected higher degree of skill by healthcare personnel and the intention to align with common international guidelines.

These guidelines draw (non-exclusively) from the consensus on resuscitation and treatment recommendations issued by the International Liaison Committee on Resuscitation1-3 which included representation from the ARC and NZRC.

These guidelines are specifically for advanced life support i.e., resuscitation with the aid of equipment and drugs to restore and maintain airway, breathing and circulation to infants and children in a hospital or other environment where cardiorespiratory arrest may be encountered. They apply to children and to all infants but not to infants at birth (newborns) (Class A, Expert Consensus Opinion).

The exact age at which paediatric techniques, particularly the compression-ventilation ratio, should replace those used for newborns is not certain, especially for small premature infants. Infants whose cardiorespiratory physiology is in transition from an intra-uterine environment at birth to several hours after birth, i.e., newborns, should be managed as per neonatal guidelines 13.1-13.10 with a compression-ventilation ratio of 3:1. Infants aged more than a few hours beyond birth should be managed according to paediatric guidelines, particularly with a compression-ventilation ratio of 15:2, in the settings of pre-hospital, emergency department, paediatric wards and paediatric intensive care unit (Class A, Expert Consensus Opinion) 2. With the exception of newborns, all infants with known or suspected cardiac aetiology of cardiac arrest should be managed according to paediatric guidelines regardless of location (Class A, Expert Consensus Opinion) 2 with a compression-ventilation ratio of 15:2 ratio if not intubated and continuous compressions without interruption if intubated 2. Infants in cardiac arrest secondary to hypoxaemia should be treated initially with positive pressure ventilation and oxygen (Class A, Expert Consensus Opinion).

Because equipment may not be immediately available, the guidelines incorporate some essential techniques of basic life support (resuscitation without equipment and drugs). Further details of basic life support for infants and children may be found in Guidelines 4-7.

As guidelines, they are neither immutable nor irrefutable prescriptions. They are not “stand-alone” documents – they do not encompass every emergency but are meant to serve as brief step-by-step guides to facilitate management of common life-threatening emergencies. Details of some techniques are described but not the details of every technique. Where scientific evidence exists, only the highest level of evidence supporting recommendations is cited.
Many recommendations are based on expert consensus opinion. These guidelines cannot replace broader education and training for paediatric emergencies.

## 2 Prevention of Cardio-Respiratory Arrest

Cardio-respiratory arrest in children is often, but not always, preceded by a period of recognizable deteriorating respiratory or cardiovascular function or both and is therefore predictable and may not be unexpected. If deterioration is recognized and treated early, cardio-respiratory arrest may be prevented. However, in institutions, barriers to recognition and treatment of a child with a deteriorating illness may exist. ANZCOR suggests the use of pediatric medical emergency team (MET) or rapid response team (RRT) systems in all hospitals that care for children (CoSTR 2015, weak recommendation, very low quality of evidence).

## 3 Definitions

Definitions of ‘infant’ and ‘child’ are based on combinations of physiology, age and physical size which influence the efficacy and practicality of performing resuscitative techniques.

The term ‘infant’ refers to a child of less than one year of age; a ‘young child’ refers to a child of pre-school and early primary school age (1-8 years); an ‘older child’ refers to a child of late primary school and early secondary school age or early teenage (9-14 years). Older children may be treated as per adult protocols but it should be noted that they do not have the same rates as adults of ventricular fibrillation as the initial dysrhythmia discovered at cardiac arrest. The guidelines do not refer in detail to the resuscitation of the newborn (newly-born) infant which may be found in guidelines 13.1 – 13.10.

## 4 Causes of Cardiorespiratory Arrest in Infants and Children

Cardiorespiratory arrest occurs in a wide variety of conditions among infants and children. The majority are caused by hypoxaemia or hypotension or both. Examples are trauma, drowning, septicaemia, sudden infant death syndrome, asthma, upper airway obstruction and congenital anomalies of the heart and lung. The initial cardiac rhythm discovered during early electrocardiographic monitoring is often severe bradycardia or asystole. The incidence of ventricular fibrillation as the initial rhythm is approximately 10%. This may influence the order of resuscitative actions. Ventricular fibrillation may occur initially with congenital heart conditions or secondary to poisoning with cardioactive drugs and it is encountered during the course of resuscitation. It may occur in membrane ion channelopathies. Respiratory arrest may occur alone, but if it is treated promptly it may not progress to cardiac arrest.

## 5 Checking Resuscitation Equipment

ANZCOR is aware of cases where equipment failure (e.g. oxygen pipes being incorrectly connected resulting in hypoxic gases being administered, and resuscitation bag valve devices incorrectly assembled) that have led to adverse outcomes. The checking and maintenance of hospital and resuscitation equipment is covered by National Standards and local policies.
Practitioners involved in resuscitation should always be alert to errors of equipment installation, assembly or use and have checking processes to minimise these risks.

References


ANZCOR Guideline 12.2 – Advanced Life Support for Infants and Children: Diagnosis and Management

**Summary**

**Who does this guideline apply to?**

This guideline applies to infants and children.

**Who is the audience for this guideline?**

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

**Recommendations**

The Australian and New Zealand Resuscitation Committee on Resuscitation (ANZCOR) make the following recommendations:

1. Cardiac arrest should be suspected in a child or infant if they are unresponsive and not breathing normally. Pulse check may be used but should not delay CPR for more than 10 seconds. If the rescuer is uncertain about the presence of a pulse then CPR should be started.

2. For a single rescuer and an unwitnessed collapse, commence CPR before seeking help.

3. For a witnessed collapse and/or multiple rescuers call for help immediately and then start CPR.

4. Rescuers should provide both ventilation and chest compressions for infant and child cardiac arrest.

5. For infants and children, CPR should commence with 2 ventilations.

6. Infant and child CPR should be delivered with a ratio of 2 breaths to 15 compressions.

7. Compressions should be delivered at a rate of 100-120/min

8. Compression depth should be approximately 1/3 the AP diameter of the chest (4cm in infants, 5cm in children).

9. A two thumb technique is preferred for delivering compressions to an infant.

10. Either one or two handed technique may be used for delivering compressions to children.
11. Vascular access should be attempted by peripheral intravenous cannula or by an intraosseous route if an IV cannot be placed within 60 seconds.

12. An ECG should be displayed (leads/pads/paddles) as soon as this can be achieved during management of the arrest.

13. Ventilation may be provided by mouth to mouth, bag-valve-mask, or more advanced airway techniques.

14. Endotracheal intubation should not be attempted or persisted with if it results in prolongation of hypoxia.

15. Following endotracheal intubation compressions should be given continuously at 100-120/min with ventilations delivered at 10 breaths/minute.

16. Drugs should be given via the IV or IO route, with the ETT used only when vascular access cannot be achieved.

17. Infants and children who have a sudden cardiac arrest should be investigated for underlying causes such as membrane channelopathies.
1 Diagnosis

Cardiorespiratory arrest should be suspected when the infant or child is unresponsive and not breathing normally. Additional signs are pallor, cyanosis and absence of pulse. Healthcare personnel may use pulse palpation in their assessment but valuable time should not be wasted. If a pulse cannot be confidently identified within 10 seconds, or there is uncertainty, cardiopulmonary resuscitation (CPR) should be commenced [Class A]. In two studies of paediatric cardiac arrest, healthcare personnel could not reliably determine the presence or absence of a pulse when other information about the presence or absence of a circulation was unknown to them [LOE III-2].

Resuscitation should commence immediately with basic techniques in the healthcare setting and continued with the aid of drugs and equipment as soon as these become available. Advanced CPR implies the preservation of a patent airway by endotracheal intubation or other device, the provision of positive pressure ventilation via mechanical devices with oxygen, the treatment of cardiac dysrhythmias, the treatment of the cause of cardiorespiratory arrest and the treatment of complications arising from its management.

Many recommendations are based on expert consensus opinion. These guidelines cannot replace broader education and training for paediatric emergencies.

2 Initial Actions

A single rescuer encountering an unwitnessed collapse of an infant or child should start CPR immediately and then obtain assistance. A rescuer witnessing a sudden collapse should obtain help immediately and then start CPR [Class B; Expert Consensus Opinion].

When several rescuers are in attendance, the initial actions e.g., bag-valve-mask ventilation/tracheal intubation and ventilation, display of the electrocardiograph and access to the circulation should be attempted simultaneously. Thereafter treatment should be guided by the cardiac rhythm. The choice and sequence of drug and fluid therapy or direct current shock is indicated in the flowchart (ANZCOR Guideline 12.3).

2.1 Electrocardiograph

The electrocardiograph may be displayed using chest leads, defibrillator paddles or pads. Drug therapy or immediate direct current shock is administered according to the existing arrhythmia while chest compressions and mechanical ventilation with oxygen are maintained.

2.2 Access to Circulation

Access to the circulation with a peripheral intravenous (IV) cannula should be attempted if not already present. However, valuable time should not be wasted (more than 60 seconds) with repeated unsuccessful attempts at cannulation because alternative safe and ready access to the circulation is possible via the intraosseous route (IO) [Class A; LOE III-1] (ANZCOR Guideline 12.6) or less effectively via the respiratory tract (endotracheal tube, ETT).
All resuscitative drugs and fluids may be given via the IV or IO route but only adrenaline, atropine and lignocaine are absorbed when given via ETT. If a central venous line exists it should be used in preference to any other route but central venous cannulation via the subclavian or internal jugular veins should not be attempted initially as it wastes time and is hazardous in this circumstance [Class A; Expert Consensus Opinion]. However cannulation of an external jugular or femoral vein may be easily accomplished. Surgical cutdown onto a peripheral vein may be required.

3 Airway

An airway should be established initially by head tilt-chin lift (Guideline 4) or jaw thrust (Guideline 4). The patency of the airway should be assessed by observation of movement of the chest and abdomen during breathing. An indrawing of the chest wall and/or distension of the abdomen with each inspiratory effort without expiration of air implies an obstructed airway. If airway obstruction is not relieved by backward head tilt-chin lift or by jaw thrust, the pharynx should be immediately inspected with the aid of a laryngoscope and cleared of any secretions, vomitus or blood with a pharyngeal sucker (e.g., Yankauer’s). Magill’s forceps may be used to extract a foreign body. Establishment and maintenance of an airway may be achieved by an oropharyngeal or nasopharyngeal airway, endotracheal tube, laryngeal mask airway or other device. An oropharyngeal airway of approximate length is the equivalent distance from the centre of the lips to the angle of the mandible. A nasopharyngeal airway of appropriate length is the equivalent distance from the tip of the nose to the tragus of the ear.

4 Breathing

If spontaneous ventilation is not immediately resumed on establishment of an airway, rescue breathing should be commenced with mouth-to-mouth ventilation, mouth-to-nose ventilation or by ventilation given by an oxygen inflated bagging circuit (bag-valve-mask), self-inflating bag (bag-valve-mask) or an operator powered resuscitator dependent on an oxygen supply. The inspiratory time should be approximately one second.

When combined with cardiac compressions, rates of ventilation are given in the table. Generally, application of breaths should precede external cardiac compression because asphyxial causes predominate over cardiac causes in paediatric cardiopulmonary arrest. However, since it is not certain if compressions or ventilations should be given first, it is reasonable in the institutional setting, if the usual equipment used to apply breaths is not immediately to hand, to commence CPR with chest compressions.

ANZCOR recommends that rescuers provide rescue breaths and chest compressions for pediatric IHCA and OHCA. If rescuers cannot provide rescue breaths, they should at least perform chest compressions (CoSTR 2015, strong recommendation, low-quality evidence). Supplemental oxygen should be administered in the mouth-to-mask and bag-valve-mask techniques.

4.1 Bag-Valve-Mask Ventilation and Endotracheal Intubation

Adequate inflation of the lungs is often possible with bag-valve-mask ventilation but this is a difficult technique for the non-expert. Bag-valve-mask ventilation is an acceptable technique if the lungs can be inflated adequately (Class B).
Bag-valve-mask ventilation was associated with fewer complications than endotracheal intubation in out-of-hospital prospective controlled studies when transport times to hospital were short \(^1\) (LOE II). Bag-valve-mask ventilation was no less appropriate than endotracheal intubation during cardiac arrest or trauma in retrospective studies \(^1\) [LOE III-2].

Intubation of the trachea has several advantages but should not be attempted at the disadvantage of prolonging hypoxaemia [Class A; Expert Consensus Opinion]. If intubation cannot be accomplished easily, oxygenation should be re-established by assisted or controlled positive pressure ventilation with a mask technique before a re-attempt at intubation. Intubation establishes and maintains a patent airway, facilitates initial mechanical ventilation with 100% oxygen and later accurate administration of lesser amounts, minimizes pulmonary aspiration and pulmonary oedema, enables suctioning of the trachea and provides a route for the administration of selected drug therapy. Intubation is more practicable for airway maintenance and ventilation than bag-valve-mask during prolonged management or transport [Class B; Expert Consensus Opinion]. After intubation, an oro- or nasogastric tube should be inserted to decompress the stomach which is often inflated by mask-delivered positive pressure ventilation.

### 5 Circulation

If the victim is unresponsive and not breathing normally chest compression should be commenced immediately [Class A; Expert Consensus Opinion]. The circulation may also be assessed by palpation of a carotid, brachial or femoral pulse [Class B; Expert Consensus Opinion]. Chest compression should be commenced if a pulse is not palpable or cannot be identified within 10 seconds, or is less than 60 beats per minute (bpm).

To give chest compression, the victim should be placed on a firm surface and compression directed to the lower sternum. The aim is to generate blood flow by sufficient compression. This may be judged by palpation of a pulse but it may be difficult to discern a pulse even during apparently effective chest compression.

#### 5.1 Depth of Compression

At least one third the anterior-posterior dimension of the chest or approximately 5 cm in children and approximately 4 cm in infants [CoSTR 2015, weak recommendation, very low quality of evidence].

#### 5.2 Method of Compression

- **Infant:** Chest compression for an infant can be performed with the two-thumb technique or two-finger technique [Class A; LOE IV]. The two-thumb technique is the strongly preferred technique for healthcare rescuers \(^1\) [Class A; Expert Consensus Opinion]. With this technique, the rescuer’s hands encircle the chest and the thumbs compress the sternum. Care should be taken to avoid restricting chest expansion during inspiration.

  The two-finger technique may be used by a single rescuer in order to minimize the transition time between chest compression and ventilation [Class B; Expert Consensus Opinion].

- **Young child:** Chest compression can be performed with the ‘heel’ of one hand or the two-handed technique \(^1\) [Class A].
• **Older child:** As for adults, using the two-handed technique [Class A; Expert Consensus Opinion].

Whatever technique is employed, pressure over the ribs and abdominal viscera should be avoided.

Approximately 50% of a compression cycle should be devoted to compression of the chest and 50% to relaxation to enable recoil of the chest wall.

### 5.3 Ratios and Sequences of Compressions And Inflations

- **Basic life support rescue** by one or two rescuer(s): 30 compressions, then 2 lung inflations [Class A; Expert Consensus Opinion].

- **Advanced life support rescue** by healthcare rescuers: 2 breaths then 15 compressions. [Class A; Expert Consensus Opinion]. Compressions may be commenced first if equipment such as bag-valve-mask is not immediately to hand.

Rescuers trained in advanced life support may use the BLS approach (30:2) in circumstances where this is more achievable. Examples might include rescuers working with others trained in the 30:2 approach, being a solo rescuer, or adverse physical environments.

If rescue breathing is given by any type of mouth technique or mask technique, breaths should be delivered during a planned pause in chest compressions to allow adequate expansion of the lungs. However, to minimize the pause for lung inflation, chest compression should be recommenced during expiratory phase of the second inflation.

Chest compressions should not be interrupted if ventilation is given via endotracheal tube. Ventilation should be given just after a compression. This will minimise but not eliminate simultaneous ventilation and chest compression [Class A, Expert Consensus Opinion]. There is no data on whether ventilation via a laryngeal mask airway (LMA) during CPR is effective if the chest is simultaneously compressed. Therefore, if using an LMA, breaths should be delivered during a pause in chest compressions as for a mouth-to-mouth (rescue breathing) or a bag-valve-mask technique [Class A, Expert Consensus Opinion].

### 5.4 Rates and Ratios of Compressions

The ideal rate of ventilation during continuous cardiac compression is not known but a rate of approximately 10 breaths per minute is recommended [Class A, Expert Consensus Opinion].

**Infant, Young and Older child**

- **Basic life support rescue:** Single or two basic life support rescuers should use a compression-ventilation ratio of ratio of 30:2 with pauses for ventilation.

  The rate of chest compression is 100-120 per minute. With pauses for ventilation, the number of compressions given each minute will be less than 100. If 5 cycles are achieved in two minutes, approximately 75-90 compressions and 5 breaths per minute would be achieved.

- **Advanced life support rescue:** For advanced rescuers, a ventilation-compression ratio of 15:2 should be used.
There should be pauses for ventilation when using bag-valve-mask ventilation or a laryngeal mask airway. Delivering 5 cycles per minute in this way will yield approximately 75-90 compressions and 10 breaths per minute.

When the airway is secured with an endotracheal tube (or tracheostomy) chest compressions should be continuous, at a rate of 100-120 compressions per minute. Ventilation should be given at 10 breaths per minute. Care should be taken to avoid hyperventilation since this compromises the effectiveness of external cardiac compression while the resultant hypocapnia may cause cerebral vasoconstriction. During uninterrupted chest compressions, ventilation should be delivered during the release phase of a compression.

6 Importance of Detection of Expired Carbon Dioxide (CO$_2$)

The amount of CO$_2$ excreted by the lungs is determined by the amount of pulmonary blood flow and ventilation. Inability to detect CO$_2$ in expired breath from a victim receiving adequate chest compression may be due to lack of ventilation and should prompt an immediate laryngoscopic check of the correct location of an endotracheal tube. Adjustment of ventilation and chest compression is facilitated with continuous measurement ($P_{ET}$CO$_2$) or intermittent detection of end-tidal CO$_2$ (when the victim has been intubated or has an LMA in place). [Class B, Expert Consensus Opinion] However, it is not presently possible to specify a $P_{ET}$CO$_2$ which predicts survival or quality of survival $^4$. (CoSTR 2015, No recommendation could be made).

Low CO$_2$ in expired breath from a victim receiving CPR may imply a treatable condition (eg: pneumothorax, hypovolaemia, cardiac tamponade) or inadequate cardiac compression or excessive ventilation or both. A high CO$_2$ in expired breath implies inadequate ventilation.

7 Investigation of Cause of Sudden Cardiac Arrest

In paediatrics, the cause of cardiac arrest is usually the result of established hypoxaemia or hypotension or both occurring in numerous diseases and traumatic events. However, occasionally cardiac arrest occurs unexpectedly in an apparently healthy child. In such cases, in addition to usual clinical investigations and coronial investigation when death is the outcome, the presence of an underlying cardiac dysrhythmia due to a disorder of membrane ion channelopathy should be considered $^1$ [Class A].
References


ANZCOR Guideline 12.3 – Flowchart for the Sequential Management of Life-Threatening Dysrhythmias in Infants and Children

Summary

Who does this guideline apply to?
This guideline applies to infants and children.

Who is the audience for this guideline?
This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

Recommendations
The Australian and New Zealand Resuscitation Committee on Resuscitation (ANZCOR) make the following recommendations:

1. The attached flow chart be used to guide the sequence of actions during infant and child cardiac arrest management.
2. Manual defibrillators are preferred at all ages for infant and child cardiac arrest.
3. In the absence of a manual defibrillator, an automated external defibrillator may be used in infants and children (preferably a model with the capability to deliver a reduced energy shock).
1 Introduction

In this flowchart, sequential actions are indicated by arrows, assuming that the preceding recommended action has been unsuccessful.

The recognition of a new arrhythmia requires transfer to the appropriate side of the flow chart at the beginning of that sequence.

The evidence for the efficacy of most drug therapy in infant/child cardiac arrest is weak or suggestive of dubious benefit. Drug therapy is secondary to good quality CPR and other interventions.

2 Drug Doses

The doses of drugs [Class A; Expert Consensus Opinion] and volume of fluid therapy are based on body weight, which in non-obese victims may be estimated according to age or height (length). In obese victims, initial doses, except selected drugs e.g. succinylcholine, should be based on ideal weight estimated from height. In obese victims, doses based on weight may cause drug toxicity. In all victims, subsequent doses should be based on clinical effects and toxicity.

2.1 Approximate weights according to age are:

Newborn: 3.5kg
1 year: 10kg
9 years and less: \((\text{age} \times 2) \text{ plus } 8\text{kg}, [2 \text{ (age } +4)]\)
10 years and over: age \times 3.3kg

Alternatively, doses of drugs, energy of DC shock and volume of fluid therapy may be prescribed on the basis of height. Drug doses according to the average of 50th percentiles of weight and height according to age for boys and girls may be read from the resuscitation table (Refer Guideline 12.4).

3 Automated External Defibrillation

Manual defibrillators are preferred in infants and children. If no manual defibrillator is available it is appropriate to use a standard Automated External Defibrillator (AED) for children over 8 yrs. For infants and children under 8 years, the order of preference is:

1. Manual defibrillator
2. AED with paediatric attenuation
3. Standard AED.
References


ANZCOR Guideline 12.4 – Medications and Fluids in Paediatric Advanced Life Support

Summary

Who does this guideline apply to?

This guideline applies to infants and children.

Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

Recommendations

1. This guideline provides detailed advice regarding the place of drugs and intravenous fluids in the management of cardiac arrest in infants and children.
1 Introduction

All intravenous (IV) and intraosseous (IO) drugs should be flushed with small boluses of 0.9% sodium chloride or 5% glucose (for amiodarone). This ensures that the drugs enter the circulation and prevents precipitation or inactivation as occurs when sodium bicarbonate mixes with calcium, or when sodium bicarbonate mixes with adrenaline (epinephrine). Medications used in paediatric CPR are listed alphabetically. See Guideline 12.5 for use in treatment of specific dysrhythmias.

2 Adrenaline (epinephrine)

Both alpha and beta effects of adrenaline (epinephrine) are useful in management of cardiopulmonary resuscitation. Alpha vasoconstrictor effects diverts blood to the cerebral and coronary circulation and can facilitate defibrillation while beta effects are chronotropic and inotropic. Although it is uncertain if survival or neurological outcome are improved by its use, it is reasonable to employ adrenaline (epinephrine) in standard dosing to achieve return of spontaneous circulation \(^2\). (CoSTR 2015, Values and Preferences)

The optimal dose and frequency of administration of adrenaline (epinephrine) in children are unknown. The initial and any subsequent dose by the intravenous or intraosseous route is 10mcg/kg, (10 micrograms/kg) with a maximum single dose of 1mg. \(^1\) [Class A; Expert Consensus Opinion]. In special circumstances such as beta-blocker use or poisoning, larger doses may be used but are otherwise not recommended.

Higher and excessive doses of adrenaline (epinephrine) may have significant complications of severe vasoconstriction, hypertension and tachydysrrhythmias. In the treatment of in-hospital paediatric arrest, administration of 100 mcg/kg after an initial 10 mcg/kg was associated with lower short-term survival than administration of first and subsequent doses of 10 mcg/kg \(^1\) [LOE II].

The systemic absorption of adrenaline (epinephrine) from endotracheal tube (ETT) administration is variable. Although unproven to be the optimal dose, 100mcg/kg is the accepted paediatric endotracheal ETT dose \(^1\) [Class A; Expert Consensus Opinion].

Adrenaline (epinephrine) is used to treat asystole, severe bradycardia, ventricular fibrillation and electromechanical dissociation. It should be given intravenously or intraosseously at intervals of 4 minutes or every second loop (Guideline 12.3) \(^1\) [Class A, Expert Consensus Opinion]. Instead of repeated bolus doses, a continuous infusion of approximately 0.1 – 0.2 mcg/kg/min or higher doses may be given – preferably into a large vein to avoid extravasation necrosis.

3 Amiodarone

Amiodarone is an antiarrhythmic drug with complex pharmacokinetics and pharmacodynamics. It may be used for shock-resistant ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT) \(^2\). The initial paediatric dose for shock-resistant
ventricular fibrillation and pulseless ventricular tachycardia is a bolus of 5 mg/kg, which may be repeated. [Class A; Expert Consensus Opinion].

There is limited evidence that lidocaine (lignocaine) may increase rates of ROSC vs. amiodarone, and that amiodarone may increase rates of survival to hospital admission vs. lidocaine (lignocaine). Studies have failed to show an association between the use of either lidocaine (lignocaine) or amiodarone and survival to hospital discharge. We suggest that either amiodarone or lidocaine (lignocaine) may be used for the treatment of pediatric shock-resistant VF/pVT \(^2\) (CoSTR 2015, weak recommendation, very low quality evidence).

Amiodarone has become the standard antiarrhythmic drug for use in paediatric shock resistant VF and pVT, and it is reasonable for this to continue in the absence of strong evidence to change practice (Expert Consensus Opinion).

In children, amiodarone can be used to successfully treat a wide range of other tachydysrhythmias, notably atrial tachycardias, (recurrent) supraventricular tachycardia, pulsatile ventricular tachycardia, junctional ectopic tachycardia [Class A; LOE III-3] and wide QRS-complex tachycardia [Class A; Expert Consensus Opinion] (Refer Guideline 12.5).

### 4 Atropine (atropine sulfate monohydrate)

Parasympathetic cardiac blockade with atropine may be indicated if bradycardia is caused by vagal stimulation or cholinergic drug toxicity\(^1\). It is uncertain if atropine reduces the incidence of bradycardia or cardiac arrest on emergency tracheal intubation or if atropine leads to increased survival or better neurological outcome\(^2\). (CoSTR 2015)

The IV or IO dose is 20mcg/kg [Class A; Expert Consensus Opinion] and the ETT dose 30 mcg/kg\(^1\) [Class A; LOE II].

Bradycardia caused by hypoxaemia should be treated with ventilation and oxygen but if unresponsive, should be treated with adrenaline (epinephrine)\(^1\).

Severe bradycardia and or bradycardia with hypotension should be treated with adrenaline (epinephrine), not atropine.

### 5 Calcium

Calcium may be used as an inotropic or vasopressor but it has no place in the management of an arrhythmia unless it is caused by hyperkalaemia, hypocalcaemia, hypermagnesaemia or calcium channel blocker\(^1\). It should not be given routinely at a cardiac arrest [Class A; Expert Consensus Opinion] and is associated with worse outcome\(^1\).

Calcium (0.15 mmol/kg) is the antidote to hypotension caused by a calcium channel blocker. The intravenous or intraosseous dose is 0.2mL/kg of 10% calcium chloride (calcium chloride dihydrate) or approximately 0.7mL/kg of 10% calcium gluconate (calcium gluconate monohydrate)(20 mg/kg). [Class A, Expert Consensus Opinion]
6 Glucose

Hypoglycaemia may be present in paediatric critical illness [LOE IV], particularly in infants. Hyperglycaemia also occurs in paediatric critical illness and is associated with increased mortality [LOE IV] but it is not known if this is the cause. The normal level is 3-8 mmol/L. The blood sugar level should be checked during CPR and after ROSC with the aim of ensuring normoglycaemia 4 [Class A; Expert Consensus Opinion]. Hypoglycaemia may be treated with 0.25g/kg glucose by IV or IO infusion with any hyperosmolar solution, for example, 0.5mL/kg of 50% (only via a central venous line) or 2.5mL/kg of 10%. Avoid extravasation, especially from peripheral veins, and avoid overdosage. The maintenance requirement to avoid hypoglycaemia in infancy is approximately 5-8 mg/kg/min.

7 Lidocaine (lignocaine)

Although lidocaine (lignocaine) has a membrane stabilizing effect and a potential to aid defibrillation, it may increase the defibrillation threshold. Lidocaine (lignocaine) may be used for the treatment of shock-resistant ventricular fibrillation or pulseless ventricular tachycardia2 (CoSTR 2015, weak recommendation, very low quality of evidence). When IV and IO access are impossible, lidocaine (lignocaine) may be given via endotracheal tube. The dose of lidocaine (lignocaine) is 1mg/kg IV, IO or ETT.

8 Magnesium

Hypomagnesaemia may cause life-threatening ventricular tachyarrhythmia, particularly when associated with hypokalaemia. Magnesium is the preferred antidysrrhythmic treatment for polymorphic ventricular tachycardia (Torsade de pointes – “Twisting of peaks”) due to acquired or congenital prolonged QT interval syndromes 3 [Class A; LOE IV]. Neither increased ROSC nor survival in adults has been demonstrated in treatment of VF with magnesium 5 [LOE IV]. The intravenous or intraosseous bolus dose of magnesium (magnesium sulfate heptahydrate) is 0.1-0.2 mmol/kg followed by an infusion of 0.3mmol/kg over 4 hours.

9 Potassium

Hypokalaemia may cause a life-threatening tachydysrhythmia. Emergency treatment is the intravenous or intraosseous administration of 0.03 - 0.07 mmol/kg by slow injection [Class A; Expert Consensus Opinion] over several minutes. If the situation is critical but not immediately life-threatening severe hypokalaemia may be treated with an infusion of 0.2 - 0.5mmol/kg/hour to a maximum of 1mmol/kg.

Extreme caution in the use of concentrated solutions of potassium is advised. Infusions should only be given by infusion pumps and frequent (half-hourly – hourly) serum monitoring with continuous ECG display is required, preferably in an intensive care unit setting. Mistakes in the calculation of potassium requirement and inadvertent administration of potassium cause avoidable deaths. (Note that a small bolus injection may cause a dangerous rise in serum potassium: a 1 mmol bolus of potassium in a 5 kg infant theoretically raises the serum level approximately 4 mmol/L). Therapies which rapidly decrease serum potassium level are intravenous glucose + insulin, inhaled or intravenous salbutamol + intravenous glucose or a combination of these agents (insulin + glucose + salbutamol) with or
without sodium bicarbonate. Sodium bicarbonate alone is the least effective therapy [LOE III-1].

## 10 Procainamide

Numerous observational studies and small case series suggest that procainamide can be used to treat haemodynamically stable supraventricular tachycardia and ventricular tachycardia in children [Class B; LOE IV]. The intravenous dose is 10-15 mg/kg infused over 30-60 minutes.

## 11 Sodium Bicarbonate

Sodium bicarbonate has a limited and unproven place in the management of cardiorespiratory arrest and routine administration is not recommended. Administration of IV or IO sodium bicarbonate neutralizes hydrogen ions in the blood but in doing so produces carbon dioxide which may re-enter cells to exacerbate intracellular acidosis.

Other deleterious effects include hypernatraemia and hyperosmolality which may depress myocardial function. Nonetheless, administration of sodium bicarbonate may be useful in severe metabolic acidosis (pH < 7.1) or prolonged arrest. The IV or IO dose is 0.5-1 mmol/kg after adequate ventilation with oxygen and chest compression have been established [Class B; Expert Consensus Opinion].

## 12 Vasopressors

Adrenaline (epinephrine) or vasopressin or a combination of vasopressors may maintain cerebral blood flow and assist return of spontaneous circulation by optimizing coronary blood flow. However, it is uncertain if survival or improved neurological outcome can be attributed to use of vasopressors (CoSTR 2015).

Although vasopressin has been used in a series of paediatric case reports it has not been investigated systematically in the paediatric age group and the optimal dose is unknown. However, by extrapolation from adult experience a bolus dose would be approximately 0.5-0.8 U/kg IV or IO [Class B; Expert Consensus Opinion].

## 13 Fluid Therapy

If hypovolaemia is suspected as the cause of cardiorespiratory arrest, intravenous or intraosseous crystalloid may be used initially for resuscitation [Class A] as a bolus of 20mL/kg. Additional boluses or colloid solution should be titrated against the response.

## References


### TABLE of DRUGS, FLUIDS, ENDOTRACHEAL TUBES and DIRECT CURRENT SHOCK FOR PAEDIATRIC RESUSCITATION

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* 50th percentiles  

## Summary

### Who does this guideline apply to?

This guideline applies to infants and children.

### Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

### Recommendations

The Australian and New Zealand Committee on Resuscitation (ANZCOR) make the following recommendations:

1. This guideline provides detailed advice regarding the management of specific dysrhythmias in infants and children.

2. High quality CPR is fundamental to management in all cases without a perfusing rhythm.

3. ANZCOR recommends a single 4J/kg shock at 2 minute intervals for ventricular fibrillation and pulseless ventricular tachycardia.

4. 3 stacked shocks (4J/kg) should be considered under special circumstances.

5. Manual defibrillators are preferred in children. If a manual defibrillator is not available it is appropriate to use a standard AED for children over 8 yrs. For infants and children under 8 years, the order of preference is:
   - Manual Defibrillator
   - AED with paediatric attenuation
   - Standard AED.

6. For cardiac arrest, adrenaline (epinephrine) is given in a dose of 10 micrograms/kg IV at 3-5 minute intervals.

7. Persistent or refractory VF or VT may be treated with amiodarone 5 mg/kg IV. This may be repeated. If amiodarone is unavailable, lidocaine (lignocaine) is a reasonable alternative.
8. In shock resistant VF, pulseless VT and PEA, early consideration should be given to correctable underlying causes.
1 Asystole or Severe Bradycardia

Asystole or pulseless severe bradycardia less than 60 bpm which is unresponsive to oxygen and ventilation or chest compressions should be treated with adrenaline (epinephrine) 10mcg/kg via intravenous (IV) or intraosseus (IO) routes [Class A; Expert Consensus Opinion]. If these routes are not available, adrenaline (epinephrine) 100 mcg/kg should be administered via the endotracheal tube (ETT) 1 but this route is the least desirable [Class A: Expert Consensus Opinion]. Possible causes should be sought and treated.

If after adrenaline (epinephrine) a perfusing sinus rhythm cannot be restored, the priority of management is continuous high quality CPR with repeated adrenaline (epinephrine) every 3-5 minutes and a consideration of potentially reversible causes. Sodium bicarbonate 1mmol/kg IV or IO may be given in cases of prolonged arrest. [Class B; Expert Consensus Opinion]. If facilities are available, pacing (oesophageal, transcutaneous, transvenous, epicardial) may be effective. Pacing should not interfere with CPR.

2 Ventricular Fibrillation and Pulseless Ventricular Tachycardia

Asynchronous multifocal ventricular contraction i.e. ventricular fibrillation (VF) produces no cardiac output. Similarly, rapid wide-QRS complex ventricular tachycardia (VT) may produce no cardiac output. The only effective treatment is direct current (DC) shock, which simultaneously depolarizes all contractile tissue and may allow resumption of sinus rhythm. If the onset of VF or pulseless VT is witnessed on an ECG monitor, such as in the ICU environment (see below), defibrillation should be attempted before any other treatment. In this circumstance also, a precordial thump may be given as a safe action (Class B; Expert Consensus Opinion), although its efficacy in children has not been proven.

The ideal energy dose for safe and effective paediatric defibrillation is unknown but present evidence supports a dose of 2-4 J/kg. 1 For the sake of simplicity ANZCOR continues to recommend 4 J/kg for the initial and subsequent doses using a biphasic (preferable) or monophasic shock for VF and pulseless VT. (CoSTR 2015, weak recommendation, very-low-quality evidence) followed immediately by 2 minutes of CPR without waiting to analyse the rhythm (see guideline 12.3, 12.6). 1

Manual defibrillators are preferred in children. If a manual defibrillator is not available it is appropriate to use a standard AED for children over 8 yrs. For infants and children under 8 years, the order of preference is:

- Manual Defibrillator
- AED with paediatric attenuation
- Standard AED.

Failure to revert to a perfusing rhythm is treated with adrenaline (epinephrine) (10 mcg/kg IV or IO or 100 mcg/kg ETT) and a subsequent single DC shock (4J/kg monophasic or biphasic shock). Persistent or refractory VF or VT may be treated with antiarrhythmics such as amiodarone 5 mg/kg IV 1 [Class A; LOE II] or IO as a bolus followed by additional DC shock.
This may be repeated. If amiodarone is unavailable as an anti-arrhythmic for DC-shock resistant VF or VT, lidocaine (lignocaine) is a reasonable alternative [weak recommendation, very low quality of evidence] in a dose of 1 mg/kg IV or IO or 2-3 mg/kg via ETT.

Adrenaline (epinephrine) (10 mcg/kg IV, IO or 100 mcg/kg ETT) should be given every second cycle of shock-2 minutes of CPR [Class B; Expert Consensus Opinion]. (Refer to Guideline 12.3, 12.4). Subsequently, refractory VF or VT may be treated with sodium bicarbonate 1mmol/kg IV or IO, magnesium (magnesium sulfate heptahydrate) 0.05-0.1 mmol/kg IV or IO, potassium chloride 0.05 mmol/kg IV or IO).

2.1 Witnessed onset of monitored VF/pulseless VT

Three stacked shocks (4J/kg, 4J/kg, 4J/kg) may be given when the onset of a shockable rhythm is witnessed with monitoring in special circumstances such as:

1) In the cardiac catheter laboratory  
2) In the intensive care unit or cardiac ward post cardiac surgery  
3) In other circumstances when a defibrillator is already attached.

Automated external defibrillators are suboptimal for this purpose because of delay to shock.

3 Pulseless Electrical Activity (PEA)

Absent pulses despite relatively normal co-ordinated electrical activity on the electrocardiograph is pulseless electrical activity (PEA), sometimes called electromechanical dissociation (EMD). It may be due to poor intrinsic myocardial contractility or it may be secondary to a number of remediable causes including hypoxaemia, hypovolaemia, hypo/hyperthermia, hyperkalaemia, hypocalcaemia, severe acidosis, pericardial tamponade, tension pneumothorax, toxins or poisons or drugs including calcium channel blocker, or massive thrombotic or gaseous pulmonary embolism.

Treatment for PEA is the administration of adrenaline (epinephrine) in an initial and any subsequent dose of 10mcg/kg IV or IO or 100 mcg/kg ETT [Class A; Expert Consensus Opinion]. Since hypoxaemia or severe acidosis are possible treatable causes, persistent PEA may be treated with an intravenous or intraosseous bolus of colloid or crystalline fluid 20 mL/kg and/or sodium bicarbonate 1 mmol/kg [Class B; Expert Consensus Opinion]. Simultaneously, an underlying cause should be sought by clinical examination and by investigation and subsequently treated. A chest radiograph, 12 lead electrocardiograph and echocardiograph (if available) should be obtained as they may be used to detect causes such as pericardial tamponade, pneumothorax, ventricular rupture or pulmonary embolism.

4 Tachydysrhythmias

Any heart rate above normal-for-age should be considered a tachydysrhythmia, particularly if associated with poor circulation and hypotension and if the patient has a history of cardiac disease, has had cardiac surgery or could have been poisoned with cardio-active drug(s). Of course, such tachycardia may be sinus tachycardia (ST) as the result, rather than the cause of poor circulation. It is important to determine the type and aetiology of the tachycardia, otherwise drug or other treatment may exacerbate the situation. A history related to the tachycardia and a 12-lead ECG should be analysed carefully.
If the rhythm diagnosis is not clear, the rate and duration of the QRS complex are starting points to differentiate sinus tachycardia (ST), ventricular tachycardia (VT), supraventricular tachycardia (SVT) and wide QRS-complex SVT. Other tachycardias such as junctional ectopic tachycardia (JET) also occur.

5 Supraventricular Tachycardia

SVT is the most common spontaneous-onset dysrhythmia in childhood and infancy. It may cause life-threatening hypotension. It is usually re-entrant with a rate of 220-300/min in infants, usually less in children (approximately 180/min). The QRS complex is usually narrow (<0.08 secs) making it difficult sometimes to discern from sinus tachycardia. However, whereas ST is a feature of other illness, SVT is a singular entity. The heart rate in ST is variable with activity or stimulation whereas in SVT it is uniform and is often of sudden onset and offset. In both rhythms, a P wave may be discernible.

If haemodynamically stable (adequate perfusion and blood pressure), initial treatment of SVT should be vagal stimulation in the supine position. For infants and young children, application to the face of a plastic bag filled with iced-water or unilateral carotid sinus massage\textsuperscript{1} [Class A; LOE IV]. Older children may be treated with unilateral carotid sinus massage or if conscious, asked to perform a Valsalva – such as blowing through a narrow straw [Class A; LOE III-1]. If mechanically ventilated, vagal stimulation may be effected by pharyngeal or tracheal suction. Eye-ball pressure should not be employed as vagal stimulation.

Drug therapy may be required. Adenosine is the drug of choice. It has a very short half-life and must be given as a rapid IV or IO bolus and flushed with 0.9% sodium chloride into the circulation. A dose in the range of 0.1 to 0.3 mg/kg converts most cases to sinus rhythm \textsuperscript{2} [Class A; LOE IV]. The initial recommended dose is 0.1 mg/kg but if this is ineffective, the dose should be increased to 0.2 mg/kg. The first dose should not exceed 6 mg and the second dose 12 mg. Few cases of adenosine-induced pro-tachyarrhythmia, eg., Torsade de pointes, have occurred.

Amiodarone may be used to treat haemodynamically stable or unstable SVT \textsuperscript{2} [Class A; LOE IV] in intravenous dosing schedules of 5 mg/kg over one hour followed by 5 mcg/kg/min or in a schedule of 25 mcg/kg/min for 4 hours followed by 5-15 mcg/kg/min. Amiodarone may cause hypotension, hypothyroidism and pulmonary toxicity.

Alternative drugs are procainamide \textsuperscript{4}, [Class B; LOE IV] digoxin, a beta blocker or a calcium channel blocker. A suitable dose for procainamide is 15 mg/kg intravenously over 30-60 minutes. Procainamide may cause hypotension by vasodilation. Calcium channel blockers should not be used to treat SVT in infants and should be avoided or used cautiously in children because they may induce hypotension and cardiac depression.

SVT may cause severe hypotension or pulselessness in which case synchronized DC shock should be given immediately in a dose of 0.5-1.0 J/kg (monophasic shock or biphasic shock) but increased to 2J/kg if necessary \textsuperscript{5} [Class A; LOE IV].

If facilities are available, overdrive pacing (oesophageal, transcutaneous, transvenous, epicardial) may be effective.
6 Pulsatile Ventricular Tachycardia

Haemodynamically stable VT may be treated with antidysrhythmic agent such as amiodarone (5 mg/kg IV over 20-60 minutes) or procainamide (15 mg/kg IV over 30-60 minutes). Note that both amiodarone and procainamide prolong the QT interval and should not be given together. If pulses are present but accompanied by hypotension and poor circulation, cardioversion is needed in which case it should be synchronised with a monophasic or biphasic DC shock dose of 0.5-2 J/kg [Class A; Expert Consensus Opinion].

6.1 Polymorphic ventricular tachycardia

If polymorphic ventricular tachycardia (Torsade de pointes, ‘twisting of peaks’) is present, magnesium (magnesium sulfate heptahydrate) (0.1–0.2 mmol/kg, 25-50 mg/kg IV) may be used 2,3 [Class A; LOE IV]. Note that this is primarily a descriptive term because of a changing axis and baseline. It may or may not be associated with a pulse. If pulseless, treat with DC shock, as for pulseless VT.

6.2 Wide QRS complex Supraventricular Tachycardia

SVT with aberrant conduction may cause a tachycardia with wide QRS complexes (>0.08 secs) and thus may be indistinguishable from VT. If pulses and blood pressure are normal the rhythm may be treated as for SVT with vagal stimulation and adenosine. If pulses are present but the blood pressure is low or circulation deemed inadequate, the rhythm should be regarded as pulsatile VT and treated with synchronised DC shock at monophasic or biphasic doses of 0.5 to 2 J/kg [Class A; Expert Consensus Opinion].

If pulses are absent, the rhythm should be regarded as pulseless VT and treated accordingly with unsynchronized DC shock at monophasic or biphasic doses of 4 J/kg 2,4. [Class A; LOE IV].

References


### Summary

**Who does this guideline apply to?**

This guideline applies to infants and children.

**Who is the audience for this guideline?**

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

**Recommendations**

1. This guideline provides detailed advice regarding the use of specific techniques during infant and child CPR and post ROSC care.
1 Airway and Oxygen Therapy

Hypoxaemia and hyperoxaemia are both deleterious. A high concentration of oxygen should be administered during resuscitation regardless of any preceding condition. There is insufficient evidence for choosing any concentration of oxygen during acute resuscitation. It is reasonable to use 100% oxygen initially for resuscitation [Class A, Expert Consensus Opinion]. After ROSC, the concentration of inspired oxygen should be reduced to a level which yields a satisfactory level of oxygen in arterial blood measured by arterial blood gas analysis (PaO₂ 80-100 mmHg) or by percutaneous oximetry (SpO₂ 94-98%). (CoSTR 2015 weak recommendation, very low quality evidence).

With cyanotic heart disease, appropriate PaO₂ and SpO₂ are approximately 40-50 mmHg and 75-85% respectively.

Oxygen may be delivered by mechanical ventilation and as a supplement to the spontaneously breathing patient by nasal cannulae, nasal prongs or face masks. In apnoeic patients the priority is to establish ventilation.

Self-inflating resuscitation bags should not be used to deliver oxygen to the self-ventilating patient because minimal and unreliable amounts of oxygen are released passively from the patient exit valve despite introduction of high flow oxygen into the resuscitation bag. If used to deliver oxygen to the spontaneously-breathing victim, an air-tight seal of the mask on the face is required, the one way delivery valve must be observed to open and ideally the reservoir bag observed to deflate periodically with self ventilation. An alternative method of oxygen delivery is desirable for the spontaneously breathing victim.

1.1 Airway Maintenance

Airway Opening Maneuuvres

Any of the basic airway opening manoeuvres (backward head tilt, chin lift [jaw support] or jaw thrust may be used) except if a neck injury is suspected, when only jaw thrust should be used [Class A, Expert Consensus Opinion]. Hyperextension of the neck, which may cause airway obstruction in small infants, should be avoided.

Oropharyngeal and nasopharyngeal airways

Airway adjuncts may be used by persons trained in selection and insertion [Class A, Expert Consensus Opinion]. Either oropharyngeal (Guedel) airways or nasopharyngeal airways may be used. A guide to the correct size of an oropharyngeal airway is the distance from the centre of the mouth to the angle of the mandible. A guide to the correct length of a nasopharyngeal airway is the distance from the tip of the nose to the tragus of the ear.

The diameter of a nasopharyngeal airway should approximate that of an endotracheal tube suitable for the child’s age.

Facemasks

To administer ventilation and oxygen, a range of mask sizes should be available.
The correct sized facemask extends from the bridge of the nose to the space between the lower lip and point of the chin. Masks with inflatable or cushioned rims are preferable because they facilitate achievement of an airtight seal of the mask upon the face.

**Laryngeal mask airway**

The laryngeal mask airway (LMA) has not been formally evaluated in paediatric resuscitation. They may be used to establish an airway and give ventilation instead of using a bag-valve-mask by persons trained in their use\(^1\) [Class B, Expert Consensus Opinion]. They should not be used in semi-conscious patients or when the gag reflex is present. They are subject to dislodgment during transport. Their use should not replace mastery of bag-valve-mask ventilation. The LMA is a suitable means of providing ventilation in situations where bag-valve-mask ventilation has failed or is inadequate and ET intubation is not possible.

Laryngeal mask airway sizes to suit body weight (kg) of newborns, infants and children are:
- size 1 <5kg; size 1\(^{1/2}\) 5-10kg; size 2 10-20kg; size 2\(^{1/2}\) 20-30kg; size 3 30-50kg; size 4 50-70kg; size 5 70-100kg; size 6 >100kg.

**Endotracheal intubation**

This technique is preferred for maintenance of the airway and provision of mechanical ventilation after initial ventilation with bag-valve-mask ventilation or LMA ventilation and to limit aspiration [Class A, Expert Consensus Opinion].

Although uncuffed tubes are routinely used in paediatrics to avoid tracheal stenosis, cuffed tubes may also be used short term since there is no difference in airway irritation or need to change the tube during anaesthesia (LOE II) \(^1\) and no difference in airway irritation between uncuffed tubes and cuffed tubes when the cuff of the latter is monitored to allow a small leak at peak inspiratory pressure in the intensive care unit [LOE III-2] \(^1\).

With uncuffed tubes, a size 3mm (internal diameter) tube is used for a term newborn of 2000-3000 g BW, a size 3.0 mm or 3.5 mm for a term newborn >3000g. A size 3.5mm or 4 mm is used for an infant up to the age of 6 months, and a size 4 mm from 7 months to 1 year. For children over 1 year, the size is approximately determined by the formula: size (mm) = age (years) / 4 + 4.

With cuffed tubes, a size 3 mm is used for newborns ≥3 kg and ≤ 1 year of age, a size 3.5 mm for children 1-2 years of age and for older children according to the formula age (years)/4 + 3.5 mm. If insertion of a cuffed tube meets tracheal resistance, a tube 0.5 mm smaller should be used. If there is no leak around a tube with its cuff deflated, a 0.5 mm smaller tube should be inserted when the patient’s condition is stable \(^1\).

Irrespective of formulae, the correct size should enable adequate lung inflation with escape of a small volume of gas around the tube on application of moderate pressure. However, cuffed tubes or closer fitting uncuffed tubes may be preferable when lung compliance is poor. Initial insertion of a cuffed tube obviates the need to change a tube when oxygenation is compromised by a leak around a tube which is too small.

The tube should be inserted to a specified length to avoid accidental extubation or endobronchial intubation. The approximate depth of insertion measured from the centre of the lips for an oral tube in a newborn is 9.0 cm, 11.5 cm for a 6 months old infant and 12 cm for a 1 year old. Thereafter, the approximate depth of oral insertion is given by the formula: age (years) / 2 + 12 cm. For nasal tubes, appropriate depths of insertion are: newborn 11 cm; 6 months 13 cm; 1 year 14 cm; thereafter age (years)/2 + 15 cm.
Although a guide, assessment of depth of intubation is not reliable during laryngoscopy because this is performed with the neck extended whereas on removal of the laryngoscope, the head assumes a position of neutrality or flexion thereby increasing depth of insertion. Initial intubation by the nasal route should not be attempted unless the oral route is obstructed. Use of cricoid pressure during intubation to prevent regurgitation should be released if it hinders intubation (Class B).

Intubation by the oral route is invariably quicker, less likely to cause trauma and haemorrhage and the tube is more readily exchanged if the first choice is inappropriate. However, orally placed tubes are more likely than nasally-placed tubes to dislodge or intubate a bronchus. The tube may be secured with cotton tape tied around the neck or affixed to the face with adhesive tape.

Confirmation of correct placement must be undertaken immediately after insertion and frequently or continuously thereafter. In emergency conditions, the oesophagus or a bronchus may be mistakenly intubated. Moreover, displacement during resuscitation or transport may occur.

The tip of the tube should be visualised passing through the vocal cords at intubation. Bilateral lung inflation should be confirmed immediately by auscultation of breath sounds in the axillae, by observation of intermittent rise and fall of the chest observed with ventilation and by return and maintenance of oxygenation. Capnography or CO$_2$ detection after initial intubation is recommended (infra) (Class A) to confirm tracheal placement with the realisation that CO$_2$ excretion cannot occur without pulmonary blood flow. Lack of CO$_2$ detection implies non-tracheal intubation or lack of pulmonary blood flow possibly due to excessive ventilation or inadequate chest compression or combinations. The position of the tube in the trachea should be checked immediately.

1.2 Delivery of Positive Pressure Ventilation

Mechanical ventilation during cardiorespiratory arrest may be given by either bag-valve-mask ventilation (BVM), laryngeal mask or by endotracheal tube depending on the training and expertise of the rescuers [Class A]. Studies of resuscitation at out-of-hospital paediatric arrest either favour BVM or show no advantage of endotracheal intubation when considering outcomes and complications.

If endotracheal intubation for mechanical ventilation can be performed expediently and expertly it confers advantages over use of a bag-valve-mask system. The tube allows administration of 100% oxygen, better control of the airway, prevention of aspiration, ability for tracheal toilet and the route may be used to administer endotracheal drugs. BVM may be given by either self-inflating resuscitation bags or oxygen flow inflating (exemplified by Jackson-Rees modified Ayre's T-piece) bags. Self-inflating resuscitation bags are recommended for the occasional resuscitator because of ease of operation. High flow oxygen should be added.

Expired air resuscitation, bag-valve-mask ventilation or ventilation by laryngeal mask airway may allow gas to enter the stomach – which may compromise effective ventilation. The stomach should be deflated with passage of nasogastric tube after endotracheal intubation [Class A, Expert Consensus Opinion].
2 Vascular Access

Any pre-existing functioning venous line can be used provided it does not contain any drug or electrolyte which caused the cardiopulmonary arrest.

2.1 Peripheral venous access

Peripheral veins are to be found on the dorsum of the hand, wrist, forearm, cubital fossa, foot and ankle (long saphenous). The external jugular is often distended during cardiopulmonary resuscitation but cannulation is impeded by performance of endotracheal intubation. Cannulation of the external jugular is facilitated when the patient is intubated and the head is turned to the opposite side. Cannulation of the femoral vein is an option facilitated by use of ultrasound. Surgical cut-down onto the long saphenous, saphenofemoral junction or basilic vein is a valuable skill sometimes required in traumatic exsanguination.

2.2 Intraosseous injection and infusion

The bone marrow has a rich blood supply and forms part of the peripheral circulation. The intraosseous route is an acceptable alternative to intravenous injection (Class A). Injected drugs are distributed as fast and attain the same plasma concentrations as those injected intravenously. Although most commonly used for young children, it can be used for patients of any age including premature newborns and adults. Establishment of the intraosseous route is quicker to achieve than the intravenous route in severely dehydrated children and fluids administered by this route stabilize vital signs as quickly as fluids given intravenously. Any intravenous fluid or drug may be administered with the aid of gravity, infused under pressure or injected from a syringe. Although many sites may be used, the antero-medial surface of the proximal or distal tibia are the most suitable puncture sites during resuscitation of infants and children.

Intraosseous needles, bone marrow injection guns and drills are manufactured for this purpose. The needle is inserted perpendicularly to the bone surface. If a hand-held needle is used, a rotary action is used to traverse the cortex. A loss of resistance signals entry to marrow.

Correct positioning of the needle, confirmed by aspiration of bone marrow or injection of 0.9% sodium chloride without extravasation, is necessary to avoid compartment syndrome. Bone marrow may be used reliably for venous biochemical and haematological analysis but not for venous blood gas tensions. Contra-indications include local trauma, infection and bone disorders.

2.3 Central venous cannulation

Cannulation of subclavian, internal or external jugular veins are options. However, central cannulation is difficult in the setting of cardiorespiratory arrest and fraught with potential serious complications such as pneumothorax unless the operator is well practised. This technique is not routinely recommended at cardiac arrest.

2.4 Endotracheal administration of drugs

The endotracheal route is an alternative if intravenous and intraosseous access are not available.
It may be the first route to become available for drug administration at the commencement of resuscitation, in which case it can be used, particularly if adrenaline is indicated.

Although adrenaline, atropine and lignocaine are all absorbed from the respiratory tree into the circulation, their absorption is variable and optimal doses are unknown. The recommended doses are adrenaline 100 mcg/kg (no human studies), lignocaine 2-3 mg/kg [LOE III-3] and atropine 30 mcg/kg [LOE II] 1,3.

Volumes of drug preparations, using water rather than saline as diluent [LOE III-3] if necessary, should be approximately 0.7mL for a newborn, 1 - 2mL for an infant, 2 - 5mL for a small child and 5 - 10mL for a large child [LOE III-2] 3.

The preparation should be injected directly into the endotracheal tube and dispersed throughout the respiratory tree with vigorous bagging. Drug administration by intrabronchial instillation achieves less plasma concentration than by simple injection into the endotracheal tube.

2.5 Other techniques

Surgical cut-down onto a long saphenous, sapheno-femoral junction or basilic vein is a valuable skill sometimes required in traumatic exsanguination.

3 Defibrillation

Defibrillators are manual or automated (AED’s), and capable of delivering either biphasic or monophasic shocks and need to be able to deliver shocks in the range of 0.5-4 J / Kg. Shocks are delivered through either pads (preferred) or paddles, the ideal size is not known, but the largest size available that still enables good separation between the pads/ paddles should be chosen to enable good contact with the chest wall.

Since defibrillators have stepped energy levels, the exact energy may not be available to conform to the dosage recommendations. In this case, the closest level to the dose should be selected. To deliver a shock, one electrode (paddle or self-adhesive pad) is placed over the cardiac apex or in the left mid-axilla opposite the xiphoid, the other to the right of the upper sternum (antero-lateral positions). Alternatively, pads/paddles may be placed in antero-posterior positions (one over the left of the lower sternum and the other below the left scapula). Self-adhesive pads, or adequate conductive gel with firm pressure on the paddles are required to deliver optimum energy through the heart and to avoid skin burns. Conductive gel should be confined to the area beneath the paddles and gel pads not permitted to touch in order to avoid bridging and ineffective delivery.

Single shocks should be delivered followed by immediate chest compressions and ventilation for 2 minutes 1 [Class A, Expert Consensus Opinion]. Three stacked shocks may be given when the onset of a shockable rhythm is witnessed with monitoring in special circumstances such as:

1) In the cardiac catheter laboratory
2) In the intensive care unit or cardiac ward post cardiac surgery
3) In other circumstances when a defibrillator is already attached.
Every effort should be made to ensure that interruption to CPR is minimal. If an AED is used, single shocks only should be used followed immediately by resumption of CPR if a pulsatile rhythm is not restored.

Rescuers must be constantly alert to the possibility of accidental electrocution of themselves or fellow-rescuers. The defibrillator should be charged only when the paddles are in position on the patient’s chest. When pads are being used the defibrillator can and should be charged while chest compressions are being carried out in order to minimise interruptions to CPR.

Two charged paddles should not be carried together in one hand. Precautions should be taken to ensure that no person is touching the patient or bed or trolley on which the patient is lying at the time of discharge. If after charging, the need for defibrillation dissipates, the charged paddles should be replaced in their holders and then discharged. Discharge should never be done in the air and never in the presence of air enriched with oxygen as there is a risk of fire.

The ideal energy dose for safe and effective paediatric defibrillation is unknown but present evidence supports a dose of 2-4 J/kg. For the sake of simplicity we continue to recommend 4 J/kg for the initial dose using a biphasic (preferable) or monophasic unsynchronised shock for VF and pulseless VT-followed immediately by 2 minutes of CPR without waiting to analyse the rhythm (CoSTR 2015, weak recommendation, very-low-quality evidence).

There is insufficient evidence from which to determine a dose for second and subsequent defibrillation energy doses. We recommend a dose of 4J/kg for second and subsequent shocks.

The external energy dose for supraventricular tachycardia (SVT) is 0.5-1J/kg, but up to 2J/kg can be used using monophasic shock or biphasic shock (LOE IV). Synchronised shocks are used. The internal energy dose is 0.5J/kg using biphasic shock [Class A, LOE IV]. The energy dose for pulsatile VT is synchronised 0.5-2J/kg [Class A, Expert Consensus Opinion].

Either pads or paddles may be used (Class A), however pads allow chest compression to continue while charging, probably permit faster resumption of chest compression after delivery of a shock, may be safer and may allow easier use of an antero-posterior position which may be more efficacious than the standard antero-lateral positions of paddles or pads. Dextrocardia may be present with congenital heart disease and the position of the paddles should be altered accordingly.

### 3.1 Automatic external defibrillation

Although a variable dose manual defibrillator is preferred, a semi-automated external defibrillator (AED) may be used for infants and children (Class A) provided it is able to differentiate shockable from non-shockable rapid paediatric rhythms. Institutions which manage infants or children should have a variable dose manual defibrillator (Class A; Expert Consensus Opinion).

If a manual defibrillator is not available for infants and small children (<8 years), use of an adult AED with dose attenuation (e.g., delivering 50J) is acceptable. If that is not available, an adult AED machine and dose should be used. For children older than 8 years, a standard AED machine (for adults) and dose may be used.
4 Monitoring

4.1 Vital signs

Routine monitoring of heart rate, respiratory rate and blood pressure are essential for infants and children with critical illness. It is prudent to have ready access to or have displayed the normal age related values for rapid reference.

4.2 Oximetry

Transcutaneous oximetry (SpO$_2$) is essential monitoring in all critically-ill patients. It equates well to arterial haemoglobin-oxygen saturation (SaO$_2$) but not when the SaO$_2$ is below 70%. The relationship between haemoglobin-oxygen saturation and partial pressure of oxygen in arterial blood (PaO$_2$) is not linear. It should be noted that a SpO$_2$ of 90%, although only 10% below normal haemoglobin-oxygen saturation, represents a partial pressure of oxygen in arterial blood (PaO$_2$) of 60 mmHg which is 40 mmHg below normal.

4.3 End-tidal CO$_2$

Studies of CO$_2$ detection during a perfusing cardiac rhythm and during resuscitation at cardiac arrest have a high level of sensitivity and specificity for tube position \(^1\) (Class A).

End-tidal CO$_2$ (P$_{et}$CO$_2$, capnography) or colorimetric detection of CO$_2$ detection are recommended \(^1\) (Class A) to confirm tube position at every tracheal intubation. Since no CO$_2$ is excreted unless there is pulmonary blood flow, undetectable CO$_2$ after intubation basically represents non-tracheal intubation or absence of circulation, or both. In this circumstance, tube position should be checked immediately by direct laryngoscopy. Low levels of end-tidal CO$_2$ during CPR may represent excessive positive pressure ventilation or inadequate chest compressions or both. In addition CO$_2$ detection during positive pressure ventilation may guard against inadvertent extubation, particularly when the intubated patient undergoes transport to, within or between hospitals. Small movements of the head and neck, as may occur for example on transfer from one trolley to another or to a bed, may easily dislodge an endotracheal tube.

4.4 Electrocardiograph (ECG)

The ECG should be displayed with either leads or paddles. Drug therapy or immediate direct current shock is administered according to the existing rhythm. Electrolyte status, especially that of potassium and calcium should be checked and may be indicated by ECG patterns.

5 Extracorporeal Life-Support (ECLS)

Institution of extracorporeal circulatory support, that is extracorporeal membrane oxygenation (ECMO) during cardiopulmonary resuscitation may be considered for infants and children in cardiac arrest from cardiac diagnoses in hospitals that have expertise, resources and systems to optimise the use of ECMO during and after resuscitation\(^5\). The upper duration of cardiac arrest which precludes ECLS is unknown. (CoSTR 2015, weak recommendation, very-low-quality evidence).
ECLS may be considered in special circumstances for out-of-hospital arrest such as in severe hypothermic environments but institutions providing an ECLS service should specify qualifying conditions and the status of the victim. The latter might include such factors as witnessed arrest, high quality CPR, duration of CPR and clinical and satisfactory acid-base condition of the victim on arrival. (Expert Consensus Opinion)

6 Special Circumstances

Infants and children with repaired or unrepaired congenital heart disease with single ventricle physiology (e.g., hypoplastic left heart syndrome), cavo-pulmonary shunts or pulmonary hypertension may require special considerations during resuscitation. However, standard CPR techniques should be used initially (Class A, Expert Consensus Opinion) pending advice from a specialist centre.

7 Chest Compression

Refer to Guidelines 6 and 12.2.

References


ANZCOR Guideline 12.7 – Management after Return of Spontaneous Circulation (ROSC)

Summary

Who does this guideline apply to?

This guideline applies to infants and children.

Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

Recommendations

The Australian and New Zealand Resuscitation Committee on Resuscitation (ANZCOR) make the following recommendations:

1. This guideline provides advice regarding post resuscitation care, prognostication, and cessation of CPR.

2. ANZCOR recommends careful attention to maintaining adequate circulation, ventilation, temperature control and normoglycaemia following ROSC.

3. There is limited evidence for specific post ROSC target values for PaO₂ or PaCO₂. ANZCOR recommends targeting normal physiological values or values appropriate to the long term condition of the individual child (e.g. cyanotic heart disease or chronic lung disease).

4. ANZCOR recommends avoiding hyperthermia post ROSC. It is acceptable to target normothermia (36-37.5°C) or hypothermia (32-34°C) in the post ROSC period.

5. ANZCOR recommends that parents/caregivers are supported to be present during resuscitation attempts for their child if they wish to do so.

6. ANZCOR recommends that staff are provided with both psychological support and skills maintenance feedback following resuscitation of infants and children.
1 Continuing Support

Supportive therapy should be provided until there is recovery of function of vital organs. This may include the provision of oxygen therapy, mechanical ventilation, parenteral fluids, inotrope infusion and renal support for several days or longer. Recovery in infants and children is usually slow because cardiorespiratory arrest is often secondary to prolonged global hypoxaemia and ischaemia which implies that other organs sustain damage before cardiorespiratory arrest. Particular care should be taken to ensure adequate cerebral perfusion with well oxygenated blood and blood pressure appropriate for age.

The cause of cardiorespiratory arrest should be sought and treated. Remediable causes include hypoxaemia, hypovolaemia, hypo/hyperthermia, electrolyte disorders including hypo/hyperkalaemia and disorders of calcium and magnesium levels, cardiac tamponade and pneumothorax (requiring relief) and toxins, poisons and drugs (requiring removal or antagonism). A membrane ion channelopathy should be considered in the case of sudden unexpected cardiac arrest.

Complications of CPR should also be sought, especially if secondary deterioration occurs. A chest radiograph should be obtained to check the position of the endotracheal tube, to detect pneumothorax, lung collapse, rib fracture or aspiration and to check if tamponade is suggested by the cardiac silhouette. A blood sample should be obtained for measurement of haemoglobin, pH, gas tensions, electrolytes and glucose. Echocardiography is useful to monitor recovery of contractility and exclude tamponade.

Regular monitoring includes that of haemodynamics, ECG, oxygenation, blood and expired carbon dioxide, blood glucose, temperature and end-organ functions.

Frequent clinical assessments should be conducted and tests performed wherever possible to determine neurological status and to assist in prognosis.

2 Blood Pressure Maintenance

Peripheral circulatory failure (shock) is common after ROSC. At least the 5th centile of blood pressure appropriate for age should be maintained with the use of parenteral fluids and inotropic-vasopressor support (CoSTR 2015, strong recommendation, very-low-quality evidence).

3 Ventilation and Carbon Dioxide Control

Although cerebral oedema could be expected after cardiac arrest, and hyperventilation is sometimes used as a temporary measure to reduce intracranial hypertension, hyperventilation results in hypocarbia which causes cerebral vasoconstriction and may impede venous return thus compromising blood pressure and consequently cerebral perfusion. Effects of blood carbon dioxide partial pressure on cerebral perfusion have not been studied after paediatric cardiac arrest.
Normocarbia should be the target of post-arrest mechanical ventilation [Class B, Expert Consensus Opinion] unless a specific patient condition requires a different PaCO₂ target \(^1\) (CoSTR 2015).

4 Oxygenation

Both hypoxaemia and hyperoxaemia are harmful. Normoxaemia should be targeted unless a different PaO₂ needs to be targeted for a patient specific condition (e.g. patients with cyanotic heart disease). ANZCOR recommends targeting the range of SpO₂ 94-98%.

5 Targeted Temperature Management (TTM)

Insufficient trials have been conducted in infants and children to determine whether hypothermia (32°C-34°C) or normothermia (36°C-37.5°C) is clearly preferable\(^1\), but therapeutic induced hypothermia for adults after VF cardiac arrest \(^2,3\) [LOE II] and for newborns after birth asphyxia \(^4,5\) [LOE I] favour induction of hypothermia to optimise neurological outcome. We suggest therapeutic temperature management (TTM) be used in the post-cardiac arrest period. While the ideal target temperature and duration are not known it is acceptable to induce hypothermia (32-34°C) or to target normothermia (36-37.5°C) \(^1\) (CoSTR 2015, weak recommendation, moderate-quality evidence). This may require use of muscle relaxant to prevent shivering, use of sedation and EEG monitoring to detect otherwise unrecognizable convulsions. TTM should be instituted within 6 hours and maintained for 24 hours and up to 72 hours in children who remain comatose after resuscitation from cardiac arrest.

Hyperthermia after cardiac arrest in adults and animals is associated with a worse neurological outcome \(^1,6,7\). Hyperthermia should be prevented and treated aggressively after cardiac arrest [Class A; Expert Consensus Opinion].

6 Glucose Control

Poor neurological outcomes in adults after cardiac arrest are associated with spontaneous and induced elevated blood glucose levels while hypoglycaemia in the newborn infant exacerbates hypoxic induced brain injury \(^6,7\). Consequently, blood glucose levels should be monitored after cardiac arrest with the aim of maintaining normoglycaemia. If insulin is used to control hyperglycaemia, care should be taken to avoid hypoglycaemia [Class B; Expert Consensus Opinion].

7 Prognosis and Prediction of Outcome

There is limited objective evidence on which to base a prognosis or to reliably foretell the outcome during paediatric resuscitation \(^1,6,7\). A factor which favours a better outcome, regardess of the location, is the observation of a shockable rhythm on the initial ECG. During in-hospital cardiac arrest an age less than one year favours a better outcome whereas during out-of-hospital cardiac arrest an age greater than one year favours a better outcome. The duration of cardiopulmonary resuscitation is not a reliable a reliable predictor of outcome.\(^1\)
Resuscitation in circumstances such as severe environmental hypothermia due to drowning in iced-water, or witnessed VF arrest, can result in better outcomes than average. It is acceptable [Class B, Expert Consensus Opinion] to continue resuscitation efforts longer in these circumstances. Long term outcome from paediatric cardiopulmonary arrest out-of-hospital is poor, but better if the arrest is respiratory alone or if cardiorespiratory arrest occurs in hospital 8,9.

In determining the prognosis after return of spontaneous circulation multiple rather than single clinical assessments and tests should be used. The latter include an electroencephalogram (within the first seven days), somatosensory evoked potentials after 72 hours, biomarkers of neuronal damage repeatedly over 72 hours, computerised axonal tomography in the initial hours and magnetic resonance imaging during the first 6 days 1. (CoSTR 2015, weak recommendation, very-low-quality evidence).

It must be kept in mind that assessments made by clinical examination may need to be modified in their timing after the use of TTM or induced hypothermia.

8 Cessation of Cardiopulmonary Resuscitation

The decision to cease cardiopulmonary resuscitation should be based on a combination of factors including but not limited to the pre-arrest status, duration of arrest, response to resuscitation, remediable factors, duration and quality of resuscitation, likely outcome, opinions of experienced personnel, desires of parents and ready availability of extracorporeal life support for in-hospital arrest.

Although there are no highly reliable means of determining outcome, available scientific studies 6,7 have shown that, in the absence of reversible causes (e.g., poisoning, hypothermia as in iced-water drowning), prolonged resuscitative efforts for children are unlikely to be successful. Severe hypothermia may confound a diagnosis of cardiac arrest. If feasible, a child in cardiac arrest out-of-hospital should be transported to hospital if there has been any ROSC during resuscitation.

If a situation is deemed futile (such as the realisation that resuscitation is prolonging death rather than saving life) or not in the child’s ‘best interests’, physicians can legally and ethically withdraw or withhold treatment, preferably with the agreement of a parent or legal guardian 10. Healthcare professionals are under no legal obligation to persist indefinitely to try to save life in this circumstance 10 (Guideline 10.5).

9 Assisting parents

Parents should be kept closely informed of events. They should be given the opportunity but not coerced to be present at the resuscitation of their child [Class B; Expert Consensus Opinion]. A staff member should be assigned to be with them and support them during the process. Although parents and relatives may take solace in having witnessed the efforts of those involved [LOE II] they may also experience emotional trauma 11. If family presence is negatively affecting the performance of the resuscitation by health-care personnel, the family should sensitively be asked to leave. 7 If resuscitation is unsuccessful or treatment is withdrawn or withheld, parents should be given the opportunity to be with their deceased child after equipment has been removed.
If a coronial enquiry is necessary, removal of devices may require permission from a coroner. Follow-up discussion should be routinely offered to parents

10 Assisting Staff

The requirement for CPR may be sudden as when a child collapses out-of-hospital and arrives unannounced to the Emergency Department or when a child’s condition deteriorates rapidly on a ward or occurs as a result of mishap. These situations always test the readiness, skills and abilities of individuals and the organisation of institutions. It is prudent to monitor performance with a view to improvement and not ignore the psychological impact which such events have on individuals. Sensitive debriefing sessions should be encouraged along with regular education.

References


